THE FUTURE OF THE LANDSAT SYSTEM

HEARINGS

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

AND THE

SUBCOMMITTEE ON INTERNATIONAL
SCIENTIFIC COOPERATION

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

FIRST SESSION

MARCH 31; APRIL 2, 1987

[No. 4]

Printed for the use of the
Committee on Science, Space, and Technology

U.S. GOVERNMENT PRINTING OFFICE
72-120 WASHINGTON : 1987

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

H701-50

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

ROBERT A. ROE, New Jersey, *Chairman*

GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
MARILYN LLOYD, Tennessee
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California
BUDDY MacKAY, Florida
TIM VALENTINE, North Carolina
ROBERT G. TORRICELLI, New Jersey
RICK BOUCHER, Virginia
TERRY BRUCE, Illinois
RICHARD H. STALLINGS, Idaho
BART GORDON, Tennessee**
JAMES A. TRAFICANT, Jr., Ohio
JIM CHAPMAN, Texas
LEE H. HAMILTON, Indiana
HENRY J. NOWAK, New York
CARL C. PERKINS, Kentucky
TOM McMILLEN, Maryland
DAVID E. PRICE, North Carolina
DAVID R. NAGLE, Iowa
JIMMY HAYES, Louisiana
DAVID E. SKAGGS, Colorado ***

MANUEL LUJAN, Jr., New Mexico*
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, Jr., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
SHERWOOD L. BOEHLERT, New York
TOM LEWIS, Florida
DON RITTER, Pennsylvania
SID W. MORRISON, Washington
RON PACKARD, California
ROBERT C. SMITH, New Hampshire
PAUL B. HENRY, Michigan
HARRIS W. FAWELL, Illinois
D. FRENCH SLAUGHTER, Jr., Virginia
LAMAR SMITH, Texas
ERNEST L. KONNYU, California
JACK BUECHNER, Missouri
JOEL HEFLEY, Colorado
CONSTANCE A. MORELLA, Maryland

Harold P. Hanson, *Executive Director*
Robert C. Ketcham, *General Counsel*
Regina A. Synder, *Chief Clerk*
R. Thomas Weimer, *Republican Staff Director*

Subcommittee on Natural Resources, Agriculture Research and Environment

JAMES H. SCHEUER, New York, *Chairman*

TIM VALENTINE, North Carolina
DAVE McCURDY, Oklahoma
HENRY J. NOWAK, New York
TOM McMILLEN, Maryland
GEORGE E. BROWN, Jr., California
(Vacancy)

CLAUDINE SCHNEIDER, Rhode Island
ROBERT C. SMITH, New Hampshire
PAUL B. HENRY, Michigan
JOEL HEFLEY, Colorado

Subcommittee on International Scientific Cooperation

RALPH M. HALL, Texas, *Chairman*

MARILYN LLOYD, Tennessee
BUDDY MacKAY, Florida
ROBERT G. TORRICELLI, New Jersey
RICHARD H. STALLINGS, Idaho
JAMES H. SCHEUER, New York
(Vacancy)

F. JAMES SENSENBRENNER, Jr., Wisconsin
SHERWOOD L. BOEHLERT, New York
RON PACKARD, California
HARRIS W. FAWELL, Illinois

---

* Ranking Republican Member.

** Resigned February 19, 1987 (H. Res. 89).

*** Elected March 30, 1987 (H. Res. 133).

CONTENTS

WITNESSES

Page

March 31, 1987:
- Joseph R. Wright, Deputy Director, Office of Management and Budget 16
- Hon. Larry Pressler, a U.S. Senator from the State of South Dakota 39
- Clarence J. Brown, Deputy Secretary of Commerce, Department of Commerce, accompanied by Mr. Anthony J. Calio, NOAA Administrator 50
- Hon. Donald C. Latham, Assistant Secretary for Command, Control, Communications and Intelligence, Department of Defense 84
- Peter M.P. Norris, executive vice president, Earth Observation Satellite Co.; Warren Nichols, director, Hughes Santa Barbara Research Center; and Charles A. Schmidt, vice president and general manager, GE/RCA Astro-Space Division 102
- Dr. Shelby G. Tilford, Director, Earth Science and Applications Division, National Aeronautics and Space Administration; Mr. Michael A.G. Michaud, Deputy Assistant Secretary for Science and Technology Affairs, Department of State; Mr. Doyle G. Frederick, Associate Director, U.S. Geological Survey; and Mr. James R. Donald, Chairman, World Outlook Board, Department of Agriculture 140

April 2, 1987:
- Dr. Frederick B. Henderson, president, Geosat Committee, Norman, OK, accompanied by Harry Stewart, Sun Exploration Corp., Dallas, TX; and Samuel W. McCandless, Jr., president, User System, Inc., Annandale, VA, representing the National Ocean Industries Association; and Dr. Thomas M. Lillesand, University of Wisconsin, Madison, WI, representing the American Society of Photogrammetry and Remote Sensing 171
- David S. Julyan, Spot Image Corp., Reston, VA 241
- Mark E. Brender, ABC-TV News, Washington, DC; and Gregory T. Koeln, Ducks Unlimited, Long Grove, IL 263
- Dr. James V. Taranik, dean, MacKay School of Mines, Reno, NV; and James J. McCarthy, Harvard University, Cambridge, MA 282
- Charles Sheffield, Earthsat Corp., Chevy Chase, MD 308
- Dr. John H. McElroy, Hughes Communications, Inc., Los Angeles, CA 317

THE FUTURE OF THE LANDSAT SYSTEM

TUESDAY, MARCH 31, 1987

House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Natural Resources, Agriculture Research and Environment and the Subcommittee on International Scientific Cooperation,

Washington, DC.

The subcommittees met, pursuant to notice, at 9:20 a.m., in room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the Subcommittee on Natural Resources, Agriculture Research and Environment) presiding.

Mr. Scheuer. The joint hearing of two subcommittees of the Science, Space, and Technology Committee will come to order. The two subcommittees are the Subcommittee on Natural Resources, Agriculture Research and Environment, which I chair, and the Subcommittee on International Scientific Cooperation, which Ralph Hall chairs, to my left.

I will chair this morning's hearing, and my distinguished cochairman of these two hearings, Congressman Ralph Hall, will chair the Thursday hearing.

At these two hearings we will take a long and hard look at the Landsat program and its prospects and problems. Since the early seventies, the United States has promoted the development of remote sensing from space at an expenditure of over $1.5 billion to date. The remote sensing program was targeted early in the Reagan Administration and in the Reagan presidency as an ideal candidate for transfer to the private sector. The Congress provided authority for that transfer in 1984.

When President Reagan signed the legislation transferring Landsat to the private sector, he commented that this bill and this program of joint chairing and joint cooperation was an excellent example of the kind of cooperation that could prevail between Congress and the Executive Branch.

Unfortunately, that cooperation was short lived. When Congress did pass a good and forward-looking bill, the Administration proved to be either unwilling or incapable of implementing it. Virtually from the start of the commercialization bill in 1984, the Administration has refused to request funding for the Landsat transfer.

Finally, OMB has requested funding for only one Landsat satellite. Our colleagues in the other body on the Appropriations Committee and on the Appropriations Committee of this House and officials at the Department of Commerce, at least until very recent days, are as one in concluding that this simply is not enough. One Landsat up there, one satellite up there simply won't do the job.

We must take steps now to solve the current funding dilemma or the U.S. Earth remote sensing satellite program, with all of its benefits to our government and to the private sector, will simply cease to exist and we will have abandoned the field of Earth remote sensing to our international competitors, the French and the Japanese.

The expertise and technology developed here will continue to be siphoned off to French and Japanese companies that do have the consistent support and assistance of their government. We have already reached the point where our Nation must fish or cut bait.

Now I would be very happy to yield to the chairman of the full Science, Space, and Technology Committee, Congressman Bob Roe.

[The prepared statement of Mr. Scheuer follows:]

STATEMENT
OF
HON. JAMES H. SCHEUER

LANDSAT HEARING
MARCH 31, 1987

THIS JOINT HEARING OF THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT AND THE SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION WILL COME TO ORDER.

THIS MORNING, AND AT A SECOND HEARING ON THURSDAY, WE WILL TAKE A LONG AND HARD LOOK AT THE LANDSAT PROGRAM. SPECIFICALLY, WE WILL EXAMINE:

- O THE COSTS OF CONTINUING THE LANDSAT SYSTEM;

- O PRESENT AND POTENTIAL USERS OF THE SYSTEM;

- O THE LEVELS OF TECHNOLOGY NECESSARY FOR LANDSAT TO COMPETE EFFECTIVELY IN THE INTERNATIONAL ARENA;

- O THE LOSS TO OUR NATION, IN TERMS OF NATIONAL SECURITY, TECHNOLOGY DEVELOPMENT AND RESOURCE DEVELOPMENT, IF WE GIVE UP ON LANDSAT;

- O AND THE CHANCES OF INCREASED INTERNATIONAL COOPERATION IN THE REMOTE-SENSING FIELD.

SINCE THE EARLY 1970'S, THE UNITED STATES HAS PROMOTED THE DEVELOPMENT OF REMOTE SENSING FROM SPACE, AT AN EXPENDITURE OF MORE THAN $1.5 BILLION DOLLARS.

THE REMOTE-SENSING PROGRAM WAS TARGETED EARLY IN THE REAGAN PRESIDENCY AS AN IDEAL CANDIDATE FOR TRANSFER TO THE PRIVATE SECTOR. THE CONGRESS PROVIDED AUTHORITY FOR THAT TRANSFER IN 1984.

WHEN PRESIDENT REAGAN SIGNED THE LEGISLATION TRANSFERRING LANDSAT TO THE PRIVATE SECTOR, HE COMMENTED THAT THE BILL WAS AN EXCELLENT EXAMPLE OF COOPERATION BETWEEN THE CONGRESS AND THE ADMINISTRATION.

UNFORTUNATELY, THAT COOPERATION WAS SHORT-LIVED. WHILE THE CONGRESS DID PASS A GOOD AND FORWARD-LOOKING BILL, THE ADMINISTRATION HAS BEEN EITHER UNWILLING OR INCAPABLE OF IMPLEMENTING IT.

VIRTUALLY FROM THE DATE OF THE COMMERCIALIZATION BILL (1984), THE ADMINISTRATION HAS REFUSED TO REQUEST FUNDING FOR THE LANDSAT TRANSFER. FINALLY, OMB HAS REQUESTED FUNDING FOR ONLY ONE LANDSAT SATELLITE.

OUR COLLEAGUES IN THE OTHER BODY AND ON THE APPROPRIATIONS COMMITTEE OF THIS HOUSE AND OFFICIALS AT THE DEPARTMENT OF COMMERCE ARE AS ONE IN CONCLUDING THAT THIS SIMPLY IS NOT ENOUGH.

WE MUST TAKE STEPS NOW TO SOLVE THE CURRENT FUNDING DILEMMA, OR THE U.S. EARTH REMOTE-SENSING SATELLITE PROGRAM, WITH ALL OF ITS BENEFITS TO OUR GOVERNMENT AND THE PRIVATE SECTOR, WILL CEASE TO EXIST.

THE EXPERTISE AND TECHNOLOGY DEVELOPED HERE WILL BE SIPHONED OFF TO FRENCH AND JAPANESE COMPANIES THAT DO HAVE THE CONSISTENT SUPPORT AND ASSISTANCE OF THEIR GOVERNMENTS.

WE HAVE REACHED THE POINT WHERE OUR NATION MUST "FISH OR CUT BAIT."

WE MUST EITHER DEVOTE THE NECESSARY RESOURCES TO FUNDING THIS VALUABLE PROGRAM, OR GIVE UP AND TURN OVER ONE MORE PRODUCT OF AMERICAN INGENUITY AND HIGH-TECH KNOW-HOW TO FOREIGN COMPETITORS.

*****

OUR FIRST WITNESS WILL BE JOSEPH WRIGHT, DEPUTY DIRECTOR OF OMB.

DESPITE THE FACT THAT MR. WRIGHT WILL ONLY BE ABLE TO BE WITH US FOR 30 MINUTES, HE HAS BEEN COURTEOUS ENOUGH TO INSURE THAT WE HAVE THE FULL BENEFIT OF HIS POSITION.

IT APPEARS AS IF OMB HAS REWRITTEN THE TESTIMONY OF EVERY GOVERNMENT WITNESS TO REMOVE ANY HINT OF SUPPORT OF THE TWO SATELLITE PLAN PUT FORTH BY THE DEPARTMENT OF COMMERCE.

INDEED MENTION OF THIS PLAN DOES NOT EVEN APPEAR IN MR. BROWN'S WRITTEN TESTIMONY.

WHILE I APPLAUD YOUR DESIRE FOR CONSISTENCY, WE HAD HOPED, WHEN WE INVITED THIS VAST ARRAY OF GOVERNMENT WITNESSES, THAT WE WOULD HEAR THEIR VIEWS NOT SIMPLY OMB'S POSITION.

Mr. Roe. Thank you, Mr. Scheuer. I too want to join in and thank both Jim Scheuer and Ralph Hall for holding this hearing. I personally and the committee considers it to be an extremely important hearing really going to the heart of the issue of the commercialization of space, it seems to the committee, looking at the broad responsibilities that we have.

In recent news articles now, they are talking about off-loading the weather satellites to be done commercially, plus the entire commercial approach to space. So the committee considers this to be extremely important, this hearing, as to what direction we will go, what kind of recommendations will be made, and as I mentioned before, I am pleased that both Mr. Scheuer and Mr. Hall are holding this joint hearing to take a look at two things.

One is why does the United States Government go into an agreement and enter into a formal agreement for commercialization and then just out of hand decide: too bad, we are not going to do it? We believe that when we make a contractual agreement and we have a program, that it ought to be followed through in the way that has been directed here and directed by the Congress.

I think the second point, which is perhaps as important as the first, is what about the future of this country in the commercialization of space? Do we turn it over to the French, do we turn it over to the Japanese, do we spend $1.5 billion of the people's money and just say: too bad, it's over now, we want to change direction, we want to do something else?

So I think, Mr. Chairman, if I may, that both you and Mr. Hall have a very important mission to perform here. We are holding intensive hearings both today and Thursday, as you know, and after we have a chance to get that data before the committee, then we will proceed in what direction the committee decides to go.

May I say for the benefit of those witnesses that are here and those people that are going to be testifying and participating with these two distinguished committees that from the chairman's point of view, we mean to forge an answer to this issue.

Either we are going to get into space or we are going to get out of it, one or the other, and what is really before the Congress now is what direction and what kind of policy will emerge as United States policy? Should it be bifurcated or should it be a joint effort between the Congress and the White House? If it is not a joint effort between the Congress and the White House, then the Congress itself will have to make the right decisions that have to be made for the future of this country.

I thank you, Mr. Chairman.

Mr. Scheuer. Thank you, Mr. Chairman.

Is Joe Wright here?

Mr. Sensenbrenner.

Mr. Hall.

Mr. Hall. I will be very brief, Mr. Chairman. I thank my cochairman and Chairman Roe.

I think it just simply should be stated that we don't want to give up our preeminence in yet another high technology field, and our failings have not been failings of technology but failings of policy, and I am very hopeful, Mr. Chairman, that the hearings today are going to enable us to build some kind of a convincing case and take the first steps in forging what really should be a meaningful and reliable government/industry partnership.

I am willing to listen to the very fine testimony that we expect to hear today and Thursday.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Hall follows:]

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

STATEMENT OF HONORABLE RALPH HALL
HEARING ON STATUS OF THE LANDSAT PROGRAM
MARCH 31, 1987

THE CONGRESS, IN PASSING THE "LAND REMOTE-SENSING COMMERCIALIZATION ACT OF 1984", KNEW THAT IT MIGHT TAKE TEN OR MORE YEARS BEFORE A FULLY SELF-SUPPORTING REMOTE-SENSING INDUSTRY DEVELOPED. THE ACT, THEREFORE, PROVIDED FOR A SMOOTH AND GRADUAL TRANSFER OF LANDSAT TO THE PRIVATE SECTOR.

UNFORTUNATELY, THAT PROCESS HAS PROVEN TO BE ANYTHING BUT SMOOTH AND GRADUAL. THE PRINCIPAL CULPRIT HAS BEEN OMB, WHICH HAS INSISTED -- VIRTUALLY SINCE THE DAY THAT THE INK DRIED ON THE LANDSAT CONTRACT -- THAT THE TRANSITION PERIOD SHOULD BE SHORTENED OR EVEN CURTAILED.

TWO THINGS TROUBLE ME ABOUT THE HALTING EFFORT TO COMMERCIALIZE LANDSAT.

FIRST, IN ALLOWING LANDSAT TO SLIP AWAY FROM US, WE ARE ABANDONING MORE THAN THE PROMISING TECHNOLOGY OF REMOTE SENSING. WE ARE ALSO CRAMPING U.S. DEVELOPMENT OF A NUMBER OF RELATED TECHNOLOGIES -- LIKE ARTIFICIAL INTELLIGENCE AND COMPUTER PROCESSING. WE CAN ILL AFFORD TO CRIPPLE THE U.S. POSTURE IN ANY HIGH-TECHNOLOGY INDUSTRY.

SECONDLY, I AM TROUBLED THAT THE U.S., UNLIKE JAPAN, CONTINUES TO HAVE DIFFICULTIES BRIDGING THE GAP BETWEEN BASIC RESEARCH AND APPLIED TECHNOLOGY. U.S. RESEARCHERS, PRINCIPALLY IN NASA AND PRIVATE INDUSTRY, DEVELOPED LAND REMOTE SENSING IN THE 1970'S. AND BECAUSE OF OUR SYSTEMIC DIFFICULTIES IN FORGING LINKS BETWEEN GOVERNMENT AND INDUSTRY, THE U.S. IS ABOUT TO GIVE UP ITS PRE-EMINANCE IN YET ANOTHER HIGH-TECHNOLOGY FIELD. OUR FAILINGS HAVE BEEN FAILINGS OF POLICY, NOT TECHNOLOGY.

IT IS STILL NOT TOO LATE TO RECAPTURE MOMENTUM IN REMOTE SENSING, BUT THE TIME LEFT TO US IS GROWING SHORT. I HOPE THAT TODAY'S HEARING, AND THURSDAY'S HEARING, WILL ENABLE US TO BUILD A CONVINCING CASE FOR LANDSAT AND TO TAKE THE FIRST STEPS IN FORGING A RELIABLE GOVERNMENT-INDUSTRY PARTNERSHIP IN THIS CRITICAL AREA OF TECHNOLOGY.

Mr. **Scheuer**. Mr. Sensenbrenner.

Mr. **Sensenbrenner**. Thank you, Mr. Chairman.

Speaking from the Republican end of this operation today, I am very happy that the chairmen have called these joint hearings because I believe that this is an important issue that the Science, Space, and Technology Committee and the Congress as a whole will have to address and address fairly soon.

I have reviewed the proposal that has come down from the Office of Management and Budget, and frankly, it just won't fly. It does not comport with the commercialization bill that was passed by Congress in 1984 and will certainly abdicate all of the research and development money which this country has spent, approximately $1.5 billion of it, to the French and the Japanese.

I don't think that people of this country will sit still for us spending large amounts of research and development money simply to allow our international competitors to use that research and development goal off after us and to further take away our technological edge.

Now, perhaps some change in the Commercialization Law of 1984 is necessary, but in terms of the fiscal year 1988 budget, there are going to have to be some rather drastic amendments to it because I am certain that the Congress is not going to poop all of this money away with a stringent first budget resolution allocation and then go after the other programs that are funded within that area with a meat ax.

I would finally point out that since the commercialization law has passed, additional uses of Landsat in the area of military intelligence and drug interdiction have been discovered. Both of these areas are obviously top priority areas for the security of the United States and the safety of our people, and to simply say that we are not going to use satellite technology in the military intelligence and drug interdiction area, in my opinion, will let the people of the United States of America down.

So I want to go on record as being strongly opposed to the administration's proposal, and I am speaking as the person who was rated last year by the National Taxpayers Union as the representative in Congress who votes most against Federal spending of all 535.

Mr. Wright, this proposal won't fly, and you better go back to the drawing boards.

Mr. **McCurdy**. Mr. Chairman.

Mr. **Scheuer**. Yes.

Mr. **McCurdy**. Mr. Chairman, I was not going to speak until I heard the eloquent statement of my colleague. I am impressed and pleased to hear his comments. I think he is right on mark. Mr. Brown and I both sit on the Intelligence Committee, and I am a member of the Armed Services Committee, and we find it intolerable to see some of the actions in the other areas in regard to Landsat, and we think it is something that should be relooked.

I certainly applaud the chairman for holding these very important hearings and look forward to the testimony.

Mr. **Scheuer**. Congressman Brown.

Mr. **George Brown**. Mr. Chairman, I ask unanimous consent to put an eloquent and strong statement in the record. [Laughter.]

Mr. SCHEUER. Your unanimous consent request is eloquently and strongly approved.

[The prepared opening statement of Mr. George E. Brown, Jr., follows:]

STATEMENT BY CONGRESSMAN GEORGE E. BROWN, JR.

Hearings on the Future of the Landsat System
Subcommittee on Natural Resources, Agriculture Research
& Environment
and
Subcommittee on International Scientific Cooperation

Mr. Chairmen, I want to thank you for calling these hearings to address the future of the Landsat system.

Over the past year, the Landsat commercialization process has come about as close as it possibly can to failing. This has not been the result of any erring on the part of EOSAT, the firm responsible for operating the two existing Landsat satellites. EOSAT has met fully its obligations under the terms of its contract with the United States government. No, the reason Landsat commercialization has come so close to the brink has to do with the government's failure to meet its obligations.

In 1985, when the Department of Commerce awarded a contract to EOSAT, Congress authorized $295 million for commercialization, to be spent over the five year period from Fiscal Year 1985 to Fiscal Year 1989. Of that amount, only $125 million has been appropriated. The will of Congress has been to keep this program on track, but the will of the Administration, to my great dismay, has been to cut EOSAT off at the knees.

The Administration requested no funding for the EOSAT contract in Fiscal Year 1986, and no funding for Fiscal Year 1987. In my view, these actions represented a near breach of contract.

But whether that breach occured then, or is about to occur today, the question before us remains the same: Does it make any sense at all to let Landsat collapse?

In my mind, it makes no sense what-so-ever. The benefits provided from remote sensing are truly substantial, not only for users within the United States, but around the world. Other nations realize this, and are moving quickly to capture a share of the market in this field. The French, Japanese, Canadians, Indians and the European Space Agency are all moving forward in developing government-subsidized remote sensing satellites. But the United States is moving backwards. Although it was the United States that developed this technology, we seem ready to abandon it to nations overseas.

It's almost as if EOSAT is being punished for its success. EOSAT has taken great strides in helping create a self-sustaining earth remote sensing industry. But the emergence of such an industry will not occur overnight. It will only come about as the result of steady and reliable support from the government. But the Administration's lack of support is doing great harm to the commercialization process.

Potential users of remotely sensed data simply cannot be expected to make the investments needed for market expansion with EOSAT's future now in question. Similarly, the nation's lending institutions cannot be expected to provide the loans necessary for capital investments in this field during a period of such uncertainty. The value-added industry is being killed by the Administration's stingy hand in this area.

Mr. Chairmen, it is my view that the nation should put its full support behind the two satellite system originally envisioned when our committee adopted the Landsat Commercialization Act three years ago. I am eager to hear from our first witness today an explanation as to why the Administration feels the original terms of the contract should not be honored.

Again, I thank you for convening these hearings.

Mr. SCHEUER. Mr. Wright, we are delighted to have you here. I personally appreciate your courtesy in agreeing to come on only two or three days' notice. You and I spoke on the telephone last Friday. It was a great courtesy.

I know you to be a brilliant and extremely able executive, and that is why I am somewhat nonplussed in hearing the administration position, and I hope very much that you can clear it up for us in your usual thoughtful and hard-hitting way.

I understand you have approximately 35 or 40 minutes with us here this morning.

Mr. WRIGHT. Yes, sir. We have got House Appropriations.

Mr. SCHEUER. We are delighted you came. Why don't you take eight or ten minutes to give us your affirmative views. Your statement will be printed in full in the record, and if you could just condense your thoughts into an eight or ten-minute period and just speak to us informally, then I am sure we will have some questions for you.

STATEMENT OF JOSEPH R. WRIGHT, DEPUTY DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET

Mr. WRIGHT. Thank you, Mr. Chairman.

I can actually do better than that. I will make it a little bit quicker. I would like to take my testimony, if I can, and just submit it in the record.

Mr. SCHEUER. Fine.

Mr. WRIGHT. Today I will speaking to you primarily, let's say, as a budget manager, if I may. I am not a technician within this area, but I see that we are properly represented by the technicians of NOAA behind me, so I am sure they can answer whatever specific questions you have got.

The Landsat program has, I think, been going through a very, very tough and confusing time. It must be confusing for the Congress because it certainly has been for us. I think, as you see, my statement basically summarizes the process that we have gone through, and it has been a convoluted process that was not made easier by the Shuttle disaster, but it is based upon the whole idea that the Federal Government rightfully spent $1 billion in order to develop the whole Landsat technology, to put up the first satellites, to transfer it from NASA over to NOAA for operations and eventual spin-off Landsat to the private sector, and then to be able to go and spend our money on further R&D development like the manned Space Station and other projects like that—That was the original concept.

I was over at the Department of Commerce as the Deputy Secretary when we were going through the first process of seeing what would be required to go and spin off Landsat to the private sector, and so therefore I can speak a little bit from the standpoint of Commerce as well as the Office of Management and Budget.

Since that time, as you know, it has been a very, very difficult time for NOAA to come up with rather clever solutions which I believe almost pushed the state of the art in terms of launch vehicles in order to come up with the funding that was in the Landsat Commercialization Act of 1984, $295 million, within what an ELV could put up in the air, and they even tried to go ahead and combine their polar satellites along with the Landsat in the OMNISTAR proposal.

That has gone back and forth. The Department of Defense has not exactly been what I would call strongly supportive in the financial area. The Department of Commerce, and the rest of the government users have not been willing to come up to the table and say that this information is valuable enough to them to the point where they will actually pay the cost.

Mr. SCHEUER. You say the other government users won't?

Mr. WRIGHT. No.

Mr. SCHEUER. I don't wish to interrupt the testimony, but they already have.

Mr. WRIGHT. Well, they have to a certain level, Mr. Chairman, but what I am saying is to the extent that additional funding would have been needed for the two satellites.

Mr. SCHEUER. Please proceed.

Mr. WRIGHT. So they were more than willing to go ahead and take the two satellites; they just weren't willing to take it out of their budgets. That is the difference. So therefore, what we have done is we have gone back on many, many proposals, and when we found that the Federal agencies were not willing to do this as well as, it looks like, many of the commercial users were not willing to go on ahead and make up for the difference, then we came back and we went down to the one satellite which we thought would make sense, to keep the Landsat going with the number 4 and number 5 that are up there, and then hopefully putting up a number 6 and then to truly test out the commercialization process.

I noticed in the House recently, the Appropriation Subcommittee, in working on the 1987 supplemental this year, made the 1987 funding request for Landsat available for two satellite programs but contingent on congressional approval of a plan that provides for the cost of the second satellite to be funded by users or sources other than NOAA.

That would take the one satellite system from a cost of $260 million, which is within the Act that was passed in 1984, and would add about another $130 million to the second satellite, and it looks to me like that is probably something that we might be able to go on ahead and work with, but then you have got to get through the Senate, and as you know, there have been some problems over there also.

So this has not been just one of the Executive Branch going back and forth with all these plans. We are trying to solve a very difficult problem. I don't think there is a question as to whether or not there is value in Landsat. I do believe there is value in the Landsat satellite system. The question is how to get it properly done and how to get this privatization process over in such a way to where it is successful but on the other hand, we don't maintain the Federal spending at this level when our agencies are not willing to go on ahead and pick it up, when the user agencies are not willing to go on ahead and pick it up out of their own budgets—That is a pretty good measure of the value that it has to those agencies.

Beyond that, I guess I want to say that I believe what we have come up with in the fiscal 1987 and 1988 budgets are good faith proposals to try and keep the program going, and beyond that, we would be more than happy to work with the subcommittee as well as the Appropriation Committees in whatever is a good, make-sense continuation of the Landsat, hopefully going toward privatization.

Thank you, Mr. Chairman.

[The prepared statement of Joseph Wright follows:]

PREPARED STATEMENT OF
JOSEPH R. WRIGHT
DEPUTY DIRECTOR
OFFICE OF MANAGEMENT AND BUDGET
BEFORE THE
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE
RESEARCH AND ENVIRONMENT
AND THE
SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
WASHINGTON D.C.
MARCH 31, 1987

Mr. Chairmen and Members of the Subcommittees: I am pleased to be here today to discuss the status of Landsat commercialization. I would first like to review the history of Landsat, the steps that have been taken to turn over the program to the private sector, and then offer my comments on the areas you have asked me to address.

HISTORY

As you are well aware, the Landsat program was originally established in NASA in the early 1970's as a research and development (R&D) program. After launching three satellites, the Government's basic R&D work at NASA was completed and the program was deemed operational. In 1979, the Department of Commerce

(DOC) was assigned responsibility for operations and eventual transfer of Landsat to the private sector. The Administration decided that additional subsidies would be required to get the private sector to take over the system. As a result, two more satellites were funded by the Government and were launched (Landsat-4 and -5) in 1982 and 1984, both of which are still in operation. By 1984, the Government had spent nearly $1 billion on the initial R&D work and ongoing operations of the program.

PRIVATIZATION STEPS

In the first budget of the Reagan Administration, the policy of transferring Landsat to the private sector was reaffirmed. The 1982 Budget established that additional satellites (beyond Landsat-4 and -5) would depend on the private sector's willingness to invest in and operate an earth resources satellite system. Agreement was reached with Congress on the privatization goal but the actual subsidy requirement was still a subject of debate. The Landsat Commercialization Act was signed into law in 1984, providing the framework for the transfer of the program to the private sector. As amended, the Act includes an authorization for additional Government subsidies of $295 million. As the issue of the actual subsidy requirement was still being debated, the President, in signing the Act, reiterated his concern that "we will make every effort to minimize the duration and amount of any Federal subsidy".

In the fall of 1985, DOC awarded a contract to a private sector operator (EOSAT, a joint venture of RCA and Hughes). A $250 million level of Government subsidy was established that was to be allocated over a four-year period, for the development, manufacture, launch, and operation of two satellites that together were to provide six years of service.

However, quickly mounting pressure to reduce the massive budget deficit under the new Gramm-Rudman-Hollings (G-R-H) law forced a reevaluation of the Government's contribution to Landsat. The 1987 President's Budget proposed to accelerate the commercialization process by withholding additional subsidies above the $125 million in seed money that had already been appropriated. A policy was established that it would be up to the competitive market to determine whether the program would continue and further financing would be the responsibility of the private interests that benefit from the program.

The Administration was severely criticized for that policy and EOSAT, along with other Landsat program advocates, argued that an acceleration of commercialization was not feasible and that additional subsidies were required. DOC began a study of alternatives for continuing Landsat without adding resources to the DOC budget. Together with EOSAT, the OMNISTAR program was conceived which proposed placing polar-orbiting weather and Landsat remote sensing instruments on single platform-type spacecraft that were to be launched and reserviced in space by the shuttle. Unfortunately, the shuttle disaster had just occurred and the Air Force decided to put the West Coast shuttle launch facility at Vandenberg in caretaker status until the mid-1990's. As a result, it was determined that large, very expensive, Expendable Launch Vehicles (ELV's) would be required. DOC went to the Defense Department for financial assistance but came back empty handed. It then became apparent that OMNISTAR was no longer feasible from a cost perspective.

In the meantime, the 1987 Continuing Resolution (CR) provided $27.5 million in additional funds for Landsat. This was after reducing by $35 million the funding previously provided for two shuttle launches. To meet the requirement in the CR, the Administration submitted a proposal for a one-satellite system using the spacecraft design specified in the original Landsat contract and a small Titan II launch vehicle. Without the prospect of Defense funding, the consequences of the Shuttle disaster, and the pressure of meeting the G-R-H deficit target, a one satellite system was deemed the best available option for the Government to propose in response to Congresssional direction that additional Federal subsidies be provided for Landsat.

The one-satellite program was advanced on the belief that commercialization could still be achieved with increased private sector investment from EOSAT and Landsat system users. The Senate, however, disagreed with that assessment and disapproved the proposal on the basis that it was not considered commercially viable.

That takes us to the present, where DOC, in response to the action taken by the Senate, has submitted another Landsat proposal to OMB for review that does not include the OMNISTAR concept. While we have not yet completed our review of that proposal, the only available sources of funding would be from reprogramming funds in Federal agency 1988 budgets including DOD, the contractor, and other Landsat system users.

Finding additional sources of funding for Landsat, outside of the Federal Government, is not a new issue. While Federal agencies and private industry continue to benefit from their purchases of Landsat data, they have not been willing to underwrite a greater share of the program costs by purchasing data in greater volumes or paying higher prices. In addition, the user groups have been unwilling to provide direct financial assistance for the program. This includes DOD which, despite DOC appeals, has been unwilling to come forward with any contributions for Landsat outside of its ongoing data purchases. DOC has also approached EOSAT for a commitment to share the financial risk of the two additional satellites with the Government. To date, EOSAT has been unresponsive and has in fact increased, not decreased, its demands for Government funding above the level originally established in the Landsat Commercialization Act.

Mr. Chairmen, and members of the Subcommittees, I want to assure you that the Administration is committed to the continuation and commercialization of Landsat. The issue is, and always has been, how much Government funding should be required to accomplish that goal. The $62.6 million requested in the 1988 President's Budget for Landsat represents what I believe to be a good faith effort to meet the requirements of the Landsat

Commercialization Act. The Government has already made over a $1 billion investment in Landsat. The technology has been proven thanks to the efforts of NASA and Commerce, and it is now time for those who argue that the program is so worthwhile and who benefit financially from it to step forward and assume the financial burden. These program supporters are not poor needy citizens. They are large corporations and countries which make use of this data.

The benefits of Landsat have been well established elsewhere. Major economic benefits are realized in the private sector by oil companies and agricultural interests, to name just two. But to date they have been willing to expend only limited resources on the program. Foreign policy and U.S. leadership in space technology is enhanced by Landsat, and quite frankly that is one of the reasons why the Government has invested over $1 billion in the program. Those benefits, however, do not justify an increased investment in the program by the Federal Government.

If Congress were to decide not to continue Landsat, I question whether the impact on the users would be significant. As a result of Landsats having mapped the earth continuously for the past 14 years, there are nearly one million scenes and films available for use in the Department of Interior EROS Data Center. In addition, land remote sensing data will still be available from U.S. allies' satellites.

I want to thank you for hearing my views on Landsat. I hope I was successful in communicating the Administration's commitment to Landsat commercialization. I also hope that the private sector would step forward, as the media has already indicated it intends to do, and develop a privately funded and operated Landsat system. This concludes my prepared remarks. I would now be happy to answer any questions you or Members of the Subcommittees may have.

Mr. **Scheuer**. Thank you very much, Joe. You and I were in Japan a couple of years ago. We had an interview with the President of one of their large machine tool companies and he told us the story of how they got into robotics, that in the late 1960's, they presented a plan to MITI, of the research and development that would be required. They told me that they wouldn't make a profit for 10 or 12 years, and MITI, the Ministry of International Trade and Industry, told them they would arrange the financing, go ahead, not to worry.

And for the first 10 or 12 years, they didn't make a profit, then around the 12th or 13th year, they broke even. The year after that, they made some money and the year after that, they were absolutely making out like gangbusters.

That was an example of the kind of government/industry cooperation to produce a product over the long pull that was deemed in Japan's best interest.

Now, here, by apparently walking away from its commitment to EOSAT, it looks like, the appearance is that OMB is saying we cannot—we will not and cannot and do not intend to enter into any long term relationship that the private sector can rely on, and we reserve the right at any time to walk away from it, if the current exigencies, the current politics make us antsy about the bottom line in the next 30, 60, 90 days, the government bottom line.

Of course, that's one reason why the Japanese have made such incredible advances over us. They have been able to fix their eye on a long term result they want to reach 10 years from now and they arranged a government/industry consortium of financing and they go for it and they can rely on each other's integrity, they can rely on each other's commitment and it's that mutual trust that enables them to make such enormous progress.

By apparently walking away from EOSAT, by apparently acting on Ed Dale's quote, as saying there was an agreement for $250 million but that's always subject to change. It shouldn't be subject to change. It was a contract. It's a tough life. Jim Miller chose to regard this as not a commitment and zeroed it out.

Do you think that kind of a philosophy is best designed to encourage any kind of privatization program that involves a long term commitment by the private industry and government, if private industry feels that based on whim and fancy, the government can walk away from its signed contractual commitments, where does that leave us, those of us who look kindly upon the process and the theory of privatization? Where does that leave us? What prospect does it have that privatization can ever be real?

Mr. **Wright**. I agree with you, Mr. Chairman. I believe that basically the government ought to hold to the contracts that it has with the private sector. I say that as a general principle. I have to say that within this Landsat and EOSAT, because I've seen most of the proposals coming in from the Department of Commerce, this has been very, very confusing, and if you take a look at not only the technological proposals but also the budget proposals, you could almost guarantee that this was going to substantially increase in costs, not because of any mistakes that were made by the Department of Commerce and NOAA or the contractor or anything else.

There were too many things that were changing on a technology standpoint. I personally don't believe this is going to end up at anything within the funding limitations that were established by the Act. I believe it is going to go substantially over that.

Mr. **Scheuer**. It may very well but the question we have to face is not whether you can precisely identify the capital costs of a 10 year research and development program or a 15 year program involving the most incredibly sophisticated technology, but whether it is important as a national goal for our country to have a presence in space.

If you say yes to that, then everything else flows from that. A government/private contractor partnership, consortium that has proved to have worked many, many times in the past and has been the basis of where we have gotten in space so far, that can work and that will work, but the will and the drive and the commitment and the integrity of the government commitment must be there, otherwise we ought to make the decision to get out of space entirely.

Mr. **Wright**. Well, which I think would be a mistake which I think you do also. A question here also is when you are in a period of time during the last year and a half where you have the severe launch problems we have had, you have to question whether or not it made sense to go along with using—let me give you an example, an ELV to put a platform up in space, where we were having the problems like we did, that as best as a layman could tell, which is the state of the art.

I'm not so sure it would have been that successful and I think we are taking a chance. On the other hand, I have to say that we put up a proposal at this time using you know, the single ELV, with the 4 and 5 that are up there at the present time, which we have just got a request for additional operations expenses for that 4 and 5, which means they are going to last a little longer, which probably makes sense from that standpoint, and I'm not saying exactly it does, because again, this is a tough area. This is not something where we are providing food stamps, to where it is pretty well proven what it does.

This is a tough area. You are pushing the state of the art. I think the proposal with the 4 and 5 up there and then also with the 6 on the single ELV, and not the platform, probably is the safest and most make-sense way to do this right now.

Mr. **Scheuer**. You think we ought to proceed on the basis of one satellite up there?

Mr. **Wright**. With the other ones that are still up there and operating.

Mr. **Scheuer**. Already beyond their expected lifetime.

Mr. **Wright**. I know that.

Mr. **Scheuer**. They could flip out at any time of the day or night.

Mr. **Wright**. Well, again, this is something for the technicians.

Mr. **Scheuer**. They are all operating beyond their originally anticipated term of life, for four scores and seven years.

Mr. **Wright**. As best I can tell, Mr. Chairman, this is probably the smartest approach to take at this stage.

Mr. **Scheuer**. What approach? Are you walking away from EOSAT? Are they going to terminate their program? Tony Calio and the Under Secretary have said if they don't get this kind of a long term deal, if you don't adhere to the contract, they are going to have to fold up shop. It's either/or.

Mr. **WRIGHT**. Well, let's take the House Appropriations Subcommittee language and let's add the funding for the single and approve the second one subject to the users going on ahead and paying for the cost of the second one, and then truly test out the privatization and say that we are willing to go ahead.

Mr. **SCHEUER**. Joe, I don't want to hog all the time. I have 4 or 5 colleagues here.

Mr. **MCCURDY**. Will the Chairman yield just on that one point, on that statement?

Mr. **SCHEUER**. Yes.

Mr. **MCCURDY**. Do I take it then that the Administration—is the gentleman endorsing the House Appropriations language?

Mr. **WRIGHT**. We sure would like to work with the House on it; yeah. The language is a general funding language. We still have a proposal that came in from Commerce that has some technical aspects of it that we want to go ahead and work with them on. But as a general approach, Congressman, if we are thinking about a combination of the Federal Government, whatever the right subsidy would be, and moving it over to the private sector, it's not all bad. You know, I thought it was kind of a make sense approach.

Now, as we have again moved back to the starting blocks on the 12 ELV's, that at one time we had with Landsat 6 and 7, away from the platform, and remember, we have gone 360 degrees on the technological proposals on this. As far as I know also, we have not had any of the other agencies, as far as I know, move off their position of increasing their funding out of their budget, particularly the Department of Defense.

Mr. **SCHEUER**. Well, the Department of Defense is expected to be buying about $10 million a year. Agriculture is buying about $4 million now. Interior, about half a million. NASA is buying about a third of a million. There are other agencies that are using this that have published their figures. I think there are some uses by government agencies that for security purposes have not been published.

It's perfectly clear that various branches of the government are interested and are paying for it now. The private sector, the oil industry, the agriculture industry, is a user. This is an industry that is in its infancy. We find it very difficult to understand why OMB can't project that this process is going to burst into wider and wider use, that we are about to see a quantum jump in its use and that with a little faith and a little stick to it, this thing will be viable, will be financially supportable by both government and private users in the not too distant future.

Mr. **WRIGHT**. Mr. Chairman, if I may just respond very quickly. I'm not saying that I disagree with you and we are not looking for a big burst of sales. We don't see that.

Mr. **SCHEUER**. In the long pull, it is going to be a steady incremental growth.

Mr. **WRIGHT**. My concern here is you are talking about a very long pull. That's my concern.

Mr. **Scheuer**. We are talking about 10 years. Is that a very long pull, 10-12 years?

Mr. **Wright**. If you are going to go ahead and the next ones are Landsat-8's and 9's and you are continuing substantially large Federal funding, I think that could be.

Mr. **Scheuer**. Presumably we wouldn't be doing that unless there was a real demand for it, unless the need was real and the demand was real, unless someone was willing to pay for it.

Mr. **Wright**. But I don't see the demand coming through. You know, like what you are talking about, that won't even cover the operating costs. That doesn't even start it.

Mr. **Scheuer**. It's not supposed to cover operating costs in the first few years. This is a long term development project.

Look, I have to yield to my colleagues. Your time is limited. I wish it weren't. I have a zillion questions to ask you, Joe. Let me yield to our ranking minority Member, Congresswoman Claudine Schneider of Rhode Island.

Miss **Schneider**. Thank you, Mr. Chairman. I would like to follow up on some of the comments that were made in reference to whether or not Landsat services were duplicative. You had mentioned in the Washington Post at one point that you felt they were. I'm curious as to if they are duplicative, how is it that the Department of Defense and the Department of Agriculture are purchasing some of the information?

Mr. **Wright**. Congresswoman, I think probably the best thing to do is ask them that question. I am not a technician on it. I do know that the Landsat photography and the multispectrum does provide you information but I do not believe the other ones do. I'm just concerned about how much I go into things I shouldn't go into at this point.

Miss **Schneider**. We will postpone that question for other witnesses.

Mr. **Wright**. It's a good question but I am not the best one to answer.

Miss **Schneider**. Insofar as the Commerce Department's proposal recommending that you support the 2 satellite system, say for example that program is approved by OMB, where would the funding be coming from? Would it be coming from the Department of Defense or NOAA or where?

Mr. **Wright**. Well, as my friends at NOAA and Commerce know, we have gone through this process for several years of working with the Department of Defense on their list of priorities and they can speak for themselves, additional funding does not fit that list. Believe me, we have tried to go and do that.

Now, I will say also in all fairness, OMB has not gone by any stretch of the imagination and tried to force this issue through the Department of Defense, we really haven't, because you are going to say they are a user and they can establish their own priorities on this, that is what we have allowed them to do. That has been one of the problems.

To be honest with you, I thought at one time that this would be of more value to Departments of Agriculture, Interior, particularly in the oil and gas, Department of Defense and all the rest. It has not proven to be that way in terms of budget dollars.

To answer your question, over on the Senate side, you know, you have a little problem here and that is when they take a look within the NOAA line on appropriations and the choice between some of the other satellite programs, the Landsat, I think, they have already shown a perference to put the funding in the other satellites.

So, from OMB's standpoint, within the Gramm-Rudman, we would be looking at it within the same account structure, which would be the satellite programs of NOAA, and that's difficult to do.

Miss **Schneider**. I can't speak for the Department of Defense and far be it for me to figure out what their priorities are. I don't think they have figured it out themselves. Insofar as NOAA is concerned, it's quite clear to my way of thinking that the National Oceanic and Atmospheric Administration is on a course to become a National Atmospheric Administration, because the number of cuts that are being made in the oceanographic area are substantial, 53 percent in ocean activities. I mean, more than half. That concerns me a great deal because it is not giving us a global picture of which Landsat plays an important role.

Insofar as NOAA's research being cut by 56 percent. That hardly speaks to our efforts and the President's commitment to making our country more competitive globally. I think when the Chairman was making reference to whether or not 10 years is too long a period of time for investment, I think not only do we have to do our cost/benefit analysis and say, well, is 10 years all right in terms of heavy research investment, but then again, what are we investing it for.

I think the purposes of Landsat, if they are not valued by the Department of Defense or by NOAA, you are saying essentially no one seems to think they have much value at all and that's why we should let it disappear. If it does, what chances are we going to have in gaining access to remote sensing information that might be generated by the French or the Japanese.

Has that issue been reviewed by OMB?

Mr. **Wright**. No. That issue specifically has not been reviewed by OMB, in the detail that you are talking about, as to where the other technology is coming from. We depend upon other agencies for that information.

I've got to say, when you talk about—the Chairman mentioned the research, for the most part, we look upon the fact that most of the Federal research has been done on the technology. That doesn't mean there aren't sophistications that are being added to it through the entire process. There are.

But, picture yourself looking at a project proposal that number one you basically agree with, the concept. There's not a disagreement with the concept. As you are sitting there looking at it, you see the costs starting to continually move up before you have even gotten through the first phases of it, you see the basic vehicle to even launch it taken away, you see proposals coming in to go launch which were good faith proposals of the Department of Commerce, they were very clever, but there's a question as to whether or not it could actually make it up there.

You are very concerned about the fact that you have invested money already and you don't want to have a satellite just sitting there that doesn't go up and you use it, and you are trying to come up with the best way that you possibly can in a very high cost escalation period of time, where there doesn't seem to be that big of a priority from the funding standpoint by the users.

That's not an easy situation to try to resolve. It really isn't.

Miss **Schneider**. I understand. I'm anxious to talk to the users. I have no further questions, Mr. Chairman.

Mr. **Scheuer**. Thank you. Joe, do I get the feeling that you would like to get off of this sticky wicket and come up here and negotiate quietly with the leading Members of the House, both on the Appropriations Committee, the Authorizing Committee, and work out some kind of a viable compromise that would preserve the integrity of that contract and enable EOSAT to move ahead?

Mr. **Wright**. Mr. Chairman, I have for the last 2 or 3 years and Congressman McCurdy and I have had many conversations on this. I've got to put it in the context that I think we want to preserve a little bit of the original intent of the transfer over to the private sector and we want to do that in the common sense way that makes sense from the taxpayers, whoever the users are going to be, all the way across the board.

I have seen many proposals in the last 3 or 4 years. We haven't seen ones, again, for outside reasons, that have held steady for any period of time.

So, yes. I would be very interested in doing it with the Department of Commerce, to come up with a proposal that I think makes sense. I don't like to see contractors out there that are depending upon the Federal Government to basically deliver on its word and have these situations change on a continued basis. That doesn't make sense at all. But I've got to say right now, we do not have a problem and I'm not so sure that just plunking a lot more Federal dollars after it is in the spirit of what was intended of the Landsat privatization.

Mr. **Scheuer**. No long term plan ever works out year by year exactly as is planned. It's above, it's below, but you know you are going to get there in 10 or 12 years. The result of our government's walking away from the EOSAT contract is they closed down their whole marketing operation. They have let 500 to 600 people go. They put their whole operation into a holding pattern. To us, it's an absolutely pitiful symbolic example of the United States being the weak kneed paralyzed giant talked about.

It is just agonizing for us to see this government/private sector partnership crumble.

Congressman Ralph Hall.

Mr. **Hall**. Thank you, Mr. Chairman.

Mr. Wright, to look at it in probably the worse context, if Landsat is allowed to die, whether at your hands or problems that you say we have in the Senate or wherever and then in lieu of the fact that in the Fall of 1985 and I do want to speak for the DOD, I want to ask this question on their behalf, in the Fall of 1985, just a few months after you approved the Landsat contract, I think you cut the requested Commerce budget for FY 1987 Landsat funding, and kicked along with that the fact that the President has on many occasions either signed legislation approving—personally approved the thrust by signing legislation or putting his initials on decision memoranda of funding for the Landsat program on at least four occasions, it seems to be his position, with that, how can we believe that U.S. interest and particularly the Department of Defense, CIA, and even oil and gas industry, in which I am very interested, would have access to any foreign remote sensing data in the future?

Can we depend on Japan and France with the present problems we have there? Just give me the benefit of your feelings on that.

Mr. WRIGHT. Well, again, Congressman, on the use of the Landsat data, I'm working with limited knowledge. You know, I don't know, as I mentioned in my testimony, I think you've got a million photographs. We've photographed the world I don't know how many times.

I would imagine from the oil and gas standpoint that that's probably going to be pretty useful for quite a few years. You don't have too many of these faults moving around, except in California.

But beyond that, for environmental purposes, sure, that changes continuously. So there would be a problem there.

I don't know what the access would be to the French updated data or the Japanese. I think you'd have to ask the Department of Commerce.

Mr. HALL. Certainly no guarantees.

Mr. WRIGHT. Well, on the guarantees, I think the guarantee is probably just what you're willing to pay for it. And again, from our point of view, we've taken a look at it, and we think that what has been proposed is a make-sense proposal under the conditions. We don't have a stable condition in space launching at the present time, that you can go on ahead and send up the very large payloads, I think, that were proposed on the OMNISTAR platform.

Now you will probably hear different opinions on that, but again, when we were looking at it, it looked like a pretty close call. And right now, going back to the original proposal of the Landsat going in for—a Landsat going up—trying to continue it within the funding levels, seems to make sense.

Now beyond that—and, by the way, would provide a continuation of data. That's what we're talking about.

Mr. HALL. I think we have several other members here, and I understand your time is short, and I appreciate your time, so I will withhold questions. If I have others, I'll submit them to you and ask you to give me a written answer.

Mr. WRIGHT. I'd be happy to.

Mr. HALL. Thank you, sir.

Mr. SCHEUER. Congressman Hefley?

Mr. HEFLEY. I have no questions.

Mr. SCHEUER. Joe, if it seems to make sense, why is EOSAT in a state of suspended animation? Why have they wiped out their marketing arm? Why are they at the point of winding down their whole operation? Why aren't we making arrangements to go ahead on this basis that seems to make sense?

Mr. WRIGHT. Well, because I think they want to go with a two-satellite system with an updated ground station. I think they believe that that is the only way that this can possibly be done.

I'm not so sure that's right. I think probably these hearings will be a good viewing of that from a technology standpoint, as well as every other purpose.

I think also you're going to find, in terms of really what is the need of the federal agencies and the other users——

Mr. SCHEUER. I think you'll find a real consensus between both Houses and both parties up here that a two-satellite system is an indispensable necessity to preserve the integrity of the flow of data. A one-satellite system is just asking for trouble.

Congressman Dave McCurdy?

Mr. MCCURDY. Thank you, Mr. Chairman.

I again appreciate Mr. Wright's willingness to testify today. He has tried to cooperate over an extended period of time. I understand the difficulty that he has from the budget standpoint, but at the same time, I think he's aware of some of the unknowns that we're facing today, and given that there is unknown about the launch vehicle and the shuttle, and I think many of the proposals that are before us are trying to address those unknown.

And if I read between the lines, I get a strong sense that the gentleman at the table at least sees one of these approaches as perhaps an interim step, as opposed to the long-term solution, that if I'm reading correctly, what you're saying is that you agree that in the near term, we should go with the next launch, the next satellite, but that we shouldn't preclude or eliminate the possibility of a second, and that, in fact, a second is really what makes sense from a commercialization standpoint; is that accurate?

Mr. WRIGHT. That could be a good way of saying it, that because of all the technical from—not the satellite; I think the R&D has pretty well been done on the Landsat—but in terms of the launch vehicles, the ground stations, the privatization, all the rest of it, as an interim step, I think you say that very well.

See, there's also a lot of confusion up here, too, I believe, in the Congress. I don't think everybody agrees like this committee does, that this funding—because remember, on the EOSAT, the CR for this year precluded the funds, you know. It actually took funds away. I think $35 million, and then added 27 in terms of the R&D.

So, you know, there has been a real uncertainty up here also.

Mr. MCCURDY. Well, the question I have, though, if I follow that point, though, in your logic, and that is, can that be done, though, in the existing contract, as you understand it?

Mr. WRIGHT. I don't——

Mr. MCCURDY. How do we preserve a contract and at the same time move to making this a commercially viable program?

Mr. WRIGHT. I'm not sure that can be done. Now my guess is—ask the Department of Commerce that's coming up, you know, after me—so my guess is, we probably cannot.

Mr. MCCURDY. Okay. Again, I'm just trying to understand where OMB stands on this. You support at least the—you support the concept of Landsat.

Mr. WRIGHT. Yes.

Mr. MCCURDY. And the difficulty you have is from a dollars standpoint and the fact that there are uncertainties with the launch.

Now if the technicians, as you refer to them, if the experts in the field can come before this committee, these subcommittees, and to a certain degree eliminate some of the questions of the risks in the outyears, then that would satisfy some of your concerns as far as the uncertainty?

Mr. WRIGHT. Yeah, but I'd like, I think—the way the House Appropriations Subcommittee has put it is a pretty good approach, because the way I read what their language is, they're saying, let's go on ahead and handle the IV and V for whatever period of time—and I agree that they have extended beyond their normal lifetime—use whatever information we can, and let's get another one up there, let's get this process going, and then you're going to start the privatization, and let's see whether or not they'll go on ahead and pick up the expenses of the second one.

That's the way I read what they came up with, and I'm saying that's not bad, which means that we would put ourselves in the interim stage that you're talking about and keep the process going.

Mr. MCCURDY. The concern that I have and I think that the Members here have expressed, and each of us has talked about the technology that's being developed by the French and by the Japanese, and for the life of me, when I see a Japanese brochure on their system, their remote sensing, when it starts out with MITI as being the lead, and then it has Fujitsu, Mitsubishi, and Hitachi and all the corporations, plus their space program, plus their energy development, that they see some real value here. And somehow that doesn't quite gel with what we're hearing from some of the other users, and maybe the cynic in me has to believe that somewhere in other agencies, that since it wasn't invented there, that they have a real problem spending their dollars on this type of information.

And what we—and since you're a budget manager and since you're a person who understands budgets, let me lay out a scenario that I think is very frightening, and that is that we mess around and that we, because of the uncertainties in the contract, the uncertainties in the launch vehicle, and the uncertainties in the politics, quite frankly, between the different agencies, that we end up with a halfbaked system. We either end up with only one satellite that doesn't make it commercial, or secondly, we end up with two satellites that are not competitive, either the TIROS that don't really move and the second—the second iteration of that bird being one that is commercially viable and competitive, whether it has radar, whether it has all these other things, the improved resolution, all these things that the Japanese and French tout, and they're going out there and advertising and marketing that—if we don't do that, then, in effect, we end up with something the Government has invested over a billion dollars into, and yet we don't have any real product.

Then some smart—and it dies—then some smart fellow in the area that Mr. Brown and I work in over in the intelligence community or DOD comes up and says, "Look, so we don't have the technology today, but we really need it. We need it for these other missions that we have, and for a mere $600 million or $700 million" that's not as—you know, it's not—it doesn't fall under the review and the scrub that these open hearings have, that we can add this technology and this capability.

And all of a sudden it's passed through. So a few years down the line, your idea of the commercialization and privatization are dead. It falls back exclusively into the government arena, and the Government controls it, and we have the either/or. We don't have a commercially viable system. The economic intelligence, which is so vital and what the Japanese are driving for, is lost, or it's controlled by one government agency.

That, to me, is not a solution. So we have to—I think it's time we called time-out for just a minute, and this is what these hearings are all about, is basically saying, now let's find out where the technology is, what the launch capabilities are or where they expect to be in the next few years, where the contracts are, because those are vital, and how the Government is willing to put up.

And when Don Latham testifies and other users come before this committee, I think you will hear from those who are close to it, that there's a need, but at the level you work, the Secretaries and above, they're not willing to put their stamp on it.

So I—that's not a question, I guess; it's a long statement. But I think it's important that we get that on the record.

And as I understand it, you don't totally disagree.

Mr. Hall. Would the gentleman yield?

Mr. McCurdy. I'd be glad to yield.

Mr. Hall. And would part of your fear be that in four or five years from now, a Colonel West or maybe a Colonel South——

[Laughter.]

Mr. Hall. A Colonel East might talk the CIA into throwing their own up there at a jillion dollars cost?

Mr. McCurdy. Well, that's—I was trying to, in a public hearing, make a general statement to that effect, and that we cannot afford for that to happen.

And as a matter of fact, I've made statements that the gentleman from California can verify, that in other areas, that if someone does that, I want them to drag my bones out from wherever they are and sit them in that chair to object and object strenuously, that that cannot occur.

And we're at a crossroads right now, and we're going to end up in that same situation. That scenario is very real, because we've seen it in other areas.

And now we have an opportunity for a minimal investment, and I say "minimal." You know, it's $350 million. I mean, that's a lot of money, and we all understand that, but in the context of the budgets we deal—my God, in Armed Services, I'd hate to tell you what we round off to.

Mr. Scheuer. In the Armed Services Committee, that would be a couple of toilets and a hammer or two. [Laughter.]

Mr. McCurdy. Well, it's not quite that bad, Mr. Chairman.

But I'm telling you, in a relative sense, that we have to keep that in mind. We need to keep that picture in focus, because we're at a crossroads now, and we don't have a lot of time, and the options don't look that good.

But I think it is time that we work out this grand strategic compromise or whatever it is.

Mr. Scheuer. Congressman George Brown?

Mr. **George Brown**. Mr. Wright, at some point, we're going to have to bring this whole subject out in the open and discuss it, and I'm going to be trying to do that very shortly, but I won't this morning.

What I'm afraid of—and all the members have indicated it—is that the United States, in terms of civilian earth remote sensing, is going to be bypassed by history very, very quickly. We're going to see a French or a Japanese or a multinational consortium with earth-observing capability in place that goes down to a meter or less and has multispectral sensing and real-time digital dataflows that anybody can get what they want out of, if they're willing to pay for it, and all the other things that we know can happen, and we're going to be dead in the water.

And in an effort to prevent that, in the '84 Act, we asked for a national plan for remote sensing, and I think probably we anticipated that we could, if we had a plan, we could solve some of these problems. That plan hasn't been produced yet, and it's 20 months overdue.

Is that your responsibility?

Mr. **Wright**. No, I—pardon me—I think that's a combined responsibility of NASA and the Department of Commerce.

Mr. **George Brown**. Well, they didn't produce it, and part of the reason is the uncertainty that is produced by OMB's handling of this commercialization thing.

There's a parallel to what could happen already going on over in the Department of Defense, where we find that all of a sudden the random access memory chips, which we invented over here, we now can buy better ones and cheaper ones from Japan, and all of a sudden we're getting very concerned about it, and DOD is going to spend several hundred million dollars trying to get us out of that whole.

That's going to happen in earth remote sensing, too, unless we look into the future a little bit to avoid it.

Is there anybody in OMB who gives a damn about the future of the United States in earth remote sensing?

Mr. **Wright**. Yes, sir, there is. If you take the amount of time that has been spent on this one subject just by the humble Deputy Director of OMB over the last four years, it's probably just about as much as any other single subject.

Mr. **George Brown**. Well, if we measure by the results that have been produced by that expenditure of time, it hasn't been a very fruitful expenditure. Maybe you'd better give up and let somebody else think about it and deal with it.

Mr. **Wright**. My guess is—no, no, no. I was going to say, my guess is, if somebody else handled it, the results wouldn't be as agreeable as we are right now.

Mr. **George Brown**. Well, obviously, you're hearing a lot of frustrated people speak here, and I'm one of the most frustrated. I commend you for keeping your cool under the circumstances.

But I am deeply disturbed about this situation. We're going to have a need for remote sensing in every area—in the scientific area, in all of the commercialization areas that we've talked about. The news media are going to get into this, and you suggest that why don't they go ahead and get in and finance it themselves.

I'll tell you why, because of the restrictions placed on what they can do by U.S. law at the present time. And what's going to happen is, they're going to avoid U.S. law by going international or something like that.

Now that's a hell of a thing to happen, and it's going to happen in the next five years. I'd like to create a sense of urgency here, if I could, about doing something, but I don't know whether I can or not.

Mr. **Wright**. Well, Congressman, I agree with much of what you're saying. We're going through some of the problems and the recent announcements and the difficulties between the countries of Japan and the United States, as you know.

However, the only thing I would caution is, I think that for the most part we all agree on what we're trying to do, maintain the Landsat system, the concept, and also successfully privatize this over a period of time. What we're really talking about is the federal subsidies, and the only question that I would ask or pose before the Committee is that you should take a look at this. It's not an easy one from the standpoint of the launch problems that have occurred, and secondly, it's not an easy one as to what is the appropriate level of federal subsidies.

And I would say that while the dollars that are in front of you may not look like they're that much, I would say, watch this over the last few years, have a very healthy distrust that they will stay where they are right now, and I don't think that the answer is just to continue federal funding forever on this.

That was not what I thought the concept was for providing the R&D and the first satellites through NASA and transferring to NOAA.

Mr. **George Brown**. Well, I think this Administration has a hangup to do about federal funding. You know, you could say the same thing about federal funding of computer chips. That's a private enterprise today. They ought to be doing the R&D on that.

Why the hell does the Defense Department have to spend a half a billion dollars subsidizing research on better RAM chips? Buy them from the Japanese.

Well, there's a point where the national security demands that we take some leadership in this kind of thing and not let ourselves get caught behind the 8-ball.

Mr. **Wright**. I agree with that, Mr. Brown.

Mr. **George Brown**. Thank you.

Mr. **Scheuer**. Congressman Packard.

Mr. **Packard**. I have no questions.

Mr. **Scheuer**. Joe, I have two questions for you on funding. Would you feel better on funding if the Japanese or the South Koreans or the Taiwanese or any other foreign group came in and made a substantial capital contribution to the funding?

Mr. **Wright**. No, I would not. It would depend. I guess you would have to say if they just made a contribution on the funding and it was going to be done somewhere along the line where I understand they are trying to work out on the Space Station, then maybe that could work out from the international cooperation standpoint and maybe it could work out very well, speaking about what happened on the funding.

So I guess from a personal standpoint—this is not the Budget Office speaking at all, but from a personal standpoint I would have to see whether or not it would be true international cooperation on it or whether or not it would be an ownership, and how the contract would be set up. But I don't think there is anything wrong with the international funding on many of these projects. We are doing it in a lot of other——

Mr. **Scheuer**. In other words, a joint venture between us and perhaps the Japanese, perhaps the French, perhaps the Koreans, perhaps the Taiwanees, or any combination of the above.

Mr. **Wright**. I think we are doing it in other areas of high tech that are probably working pretty well. I wouldn't have a bias against it, but I guess——

Mr. **Scheuer**. You would be open minded.

Mr. **Wright**. Sure.

Mr. **Scheuer**. Joe, the Department of Commerce, Clarence Brown, affectionately known to us as Bud Brown, indicated in a March 4th letter to you that the Landsat commercialization wouldn't be possible "without an administration commitment to a second satellite and additional subsidies." Do you agree, and if you don't, why don't you?

Mr. **Wright**. I would prefer not to answer that question yet. The staff hasn't provided me the analysis on it. My guess is this is not going to be a long, prolonged process. We are only a couple of weeks away.

Mr. **Scheuer**. You think that will be resolved in the next couple of weeks?

Mr. **Wright**. I sure do.

Mr. **Scheuer**. Very good.

Let me just say for the record that the EOSAT subsidy has gone from about $250 million in 1985 to about $297 million or $300 million in the following 18 months, which reflects the damage that the Challenger accident caused, including that delay. So you can't really say that costs have gone off the chart and out of control. I might say that probably the funding is negotiable.

It seems to me that all of our experience indicates that in a long-term, extremely complicated and sophisticated high tech enterprise in space, it is very difficult to establish very fine parameters of what the annual subsidy is going to be. The fact is they have kept very good control over the parameters of the annual subsidies.

They haven't gone out of control, and it seems to me, to take the point that George Brown and Dave McCurdy made, this is a national venture of the first order of magnitude of importance to our national psyche, to our national security, to our national economics, and it seems to me that the concept of a government/private sector joint venture is sound, it is proven, it has operated in this venture under unusually difficult circumstances about as responsibly and accurately within the confines that have been anticipated as most of the others.

If you look at the variations in cost of Defense Department systems—and I mention facetiously a couple of toilet seats and a hammer or two—they have gone off the chart astronomically, whereas this has been really pretty much as it was hewed out originally.

I think they are getting a feeling up here, to a man, both sides of the aisle, that we hope this thing can be worked out. Frankly, the thing that gives me as much confidence as anything else is to have a person, an executive of your talent, of your high intellectual brain power and your commitment to the national good sitting in the catbird's seat.

We hope that in the next two or three weeks all these terrific personal qualities of yours that I have come to know and respect will be zeroed in on producing a constructive answer.

Does anybody else have a final remark or question?

Mr. HALL. Yes, Mr. Chairman. I just want to congratulate you on smoothing Mr. Wright into giving us an hour instead of 30 minutes.

Mr. WRIGHT. They have probably funded another 100 housing projects downstairs.

Mr. SCHEUER. George? Okay.

Joe, thank you very, very much. We appreciate your coming.

Senator Pressler, we are very grateful to you for coming, and we are grateful for your patience in permitting us to move Joe Wright ahead of you. We are grateful for your understanding.

Senator PRESSLER. I enjoyed listening.

Mr. SCHEUER. You come here as a former member whom we respect and admire and as a member who has shown longstanding commitment for the Landsat. I think you testified here in 1982 or 1983. You have been at this mission for at least five years, so you come to us as a guy who has knowledge, experience, and who has stuck with it. We respect you for that and we welcome your testimony.

Your prepared testimony will be reprinted in full at this point in the record, so please feel free for seven or eight minutes.

STATEMENT OF HON. LARRY PRESSLER, A U.S. SENATOR FROM THE STATE OF SOUTH DAKOTA

Senator PRESSLER. Mr. Chairman, I shall be very brief——

Mr. Chairman, Members of the Committee, Members of my former Committee, let me first thank you very much for this opportunity, and thank you for your excellent work. I very much enjoyed listening to the exchange with OMB.

I have returned here several times since my service on this committee as a House member. It is hard for me to stay away; but it is always the same issue that brings me back here. I believe the last time I was here we were talking about Landsat commercialization. That has not worked out quite as well as many of us would have liked.

Today we are discussing the broader issue of whether we will retain a Landsat program at all, and if so, under what conditions and with what goals. These issues are of the greatest importance to the entire nation, and their timely resolution is essential.

The great uncertainty and volatility associated with our national Landsat policy has already cost us dearly in terms of world leadership in land remote sensing, and we can expect to lose a great deal more ground if the matter is not resolved soon. So I applaud you for your continued leadership in this area, Mr. Chairman.

Today I would like to discuss not only how we could shape future Landsat policy but also the need to address problems facing current Landsat operations—which I feel have been largely ignored as a result of uncertainty associated with the program's future. Let me begin by addressing the latter.

It should not be forgotten that we have two operating Landsat satellites in orbit today, as has been pointed out. Landsats 4 and 5 continue to collect and transmit valuable data even though they have surpassed their nominal life expectancy of three years. Landsat 5 was scheduled to expire this year, but every indication is that both satellites will exceed their life expectancy through fiscal year 1988.

The problem is that the administration's fiscal year 1988 budget request provides no funding to continue the operation of either of these satellites for the archiving, processing and distribution of data from them in previous Landsats. This must be corrected. Senator Riegle and I, as chairman and ranking member of the Senate Subcommittee on the Science, Space, and Technology Committee, have contacted both OMB and the Department of Commerce in an attempt to get this problem resolved.

I ask that those letters be made a part of today's record—that is, Senator Riegle's and my letters—and urge this committee to join us in making certain that sufficient operations money for fiscal year 1988 is included in this year's budget.

Mr. **Scheuer**. That is just for operations of the satellites up there? You are not talking about additional money to continue the sixth and the seventh, to put the sixth and the seventh up there.

Senator **Pressler**. That is right.

Mr. **Scheuer**. That is a separate question.

Senator **Pressler**. That is correct.

Mr. **Scheuer**. All right.

Senator **Pressler**. It would look pretty silly for us to have two perfectly good satellites floating around in space unused because we have failed to provide operating funds. It would be kind of like buying an air conditioner and forgetting to plug it in.

In addition, I am somewhat distressed at the lack of progress we have made on government R&D of Landsat data in the wake of commercialization. The 1984 Landsat Commercialization Act calls for a continued government role in scientific and technological R&D. In addition, it calls for the establishment of a national land remote sensing archive to support this research effort.

I have a parochial interest in this issue, Mr. Chairman, since that archive is to be the EROS Data Center in my home state, and I expect that EROS' talented scientists would be quite active in the research programs, but it is extremely important to our overall national policy that we maintain a strong scientific program.

We have been moving too slowly in that area and need to be more aggressive in maintaining our technological superiority in land remote sensing research and applications. This is another area I hope this committee will look into, and it leads into the second part of my statement concerning the long-range goals of the Landsat program.

As much as I would like to believe otherwise, the Landsat program remains unviable as a commercial concern. We have to quit playing with numbers and face the facts. The French cannot make a go of it without government support; neither can we. I very much enjoyed the exchange between my former colleague, Congressman Brown, and the OMB Director on that point.

This is evidenced in the substantial subsidy payments associated with the 1984 Commercialization Act. This is not to say it should not be commercialized or cannot be commercially viable in the future, and it certainly should not be interpreted as a justification for scrapping the Landsat program. Although I have been skeptical of commercialization, I have always strongly believed in the Landsat program.

The problem is that too many people have approached the issue with the blinders of commercial viability. The importance of the Landsat programs goes well beyond its commercial or economic value. We need to look to it for its scientific and technological importance as well.

To the extent commercialization can lessen program costs to the government—great, I am all for it, but in weighing the program's future, we need to consider its tremendous scientific and technological contributions. It would be extremely short sighted to scrap the program if it proves to be commercially unviable. We already have invested $1.5 billion pioneering the program and gaining the worldwide leadership we enjoy today. We have already sacrificed too much of that leadership by our indecision and perceived non-support for the program.

I cannot emphasize enough the technological and scientific importance of Landsat in understanding the planet on which we live. For example, the present and future Landsat data are key ingredients for performing Earth Systems Science Studies. This is an area in which NASA has become increasingly interested, and I applaud them for that.

The maintenance of an historical archive, the acquisition of new data and the technological and scientific advancements made in processing and analyzing these data are essential to the adequate study of Earth, its systems and its global processes.

We are spending billions of dollars on four expeditions to our sister planets in this solar system, but we continue to neglect our own backyard on the planet Earth, which could yield information many times more valuable than that collected from Mars and other planets.

So we need to keep the scientific aspect of the program strong. We need to continue research and development efforts. We cannot forego its scientific and technological contributions simply because it cannot make its own in the marketplace.

That is my primary message today. Let's quit looking at this issue with the blinders of commercialization and give greater recognition to Landsat's scientific and technological importance. The commercial entity cannot pick up that slack.

Mr. Chairman, in conclusion, our commitment in this area must remain strong, and we need to let the world know that the United States is going to be in this business for the long term.

With that, I will be glad to answer any questions. I ask unanimous consent to place letters from Senator Riegle and me, two letters, to make it a part of my testimony.

Thank you very much, Mr. Chairman.

Mr. SCHEUER. There being no objection, so ordered.

[The prepared statement of Senator Pressler follows:]

STATEMENT OF SENATOR LARRY PRESSLER (R-SD)
BEFORE THE HOUSE COMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE
REGARDING THE FUTURE OF THE LANDSAT PROGRAM
MARCH 31, 1987

Mr. Chairman, let me first thank you for the opportunity to testify before this Committee today. I have returned here several times since my service on this Committee as a House Member. It is hard for me to stay away, but it is always the same issue that brings me back.

I believe the last time I was here we were talking about Landsat commercialization. That has not worked out quite as well as many of us would have liked. Today, we are discussing the broader issue of whether we will retain a Landsat program at all, and if so, under what conditions and with what goals. These issues are of the greatest importance to the entire nation, and their timely resolution is essential. The great uncertainty and volatility associated with our national Landsat policy has already cost us dearly in terms of world leadership in land remote sensing, and we can expect to lose a great deal more ground if the matter is not resolved soon. So I applaud you for your continued leadership in this area.

Today, I would like to discuss not only how we should shape future Landsat policy, but also the need to address problems facing current Landsat operations--which I feel have been largely ignored as a result of uncertainty associated with the program's future. Let me begin by addressing the latter.

CURRENT PROGRAM PROBLEMS

It should not be forgotten that we have two operating Landsat satellites in orbit today. Landsats-4 and -5 continue to collect and transmit valuable data, even though they have surpassed their nominal life expectancy of three years. Landsat-5 was scheduled to expire this year, but every indication is that both satellites will exceed their life expectancy through FY88. The problem is that the Administration's FY88 budget request provides no funding to continue the operation of either of these satellites or the archiving, processing, and distribution of data from them and previous Landsats. This must be corrected. Senator Riegle and I--as Chairman and Ranking Member of the Senate Subcommittee on Science, Space, and Technology--have contacted both OMB and the Department of Commerce in an attempt get this problem resolved. I ask that those letters be made part of today's hearing record, and urge this Committee to join us in making certain that sufficient operations money for FY88 is included in this year's budget. It would look pretty silly for us to have two perfectly good satellites floating around in space, unused because we failed to provide operating funds. It would be kind of like buying an air conditioner and forgetting to plug it in.

In addition, I am somewhat distressed at the lack of progress we have made on government R&D of Landsat data in the wake of commercialization. The 1984 Landsat Commercialization Act calls for a continued government role in scientific and technological R&D. In addition, it calls for the establishment of a national land remote sensing archive to support this research effort. I have a parochial interest in this issue since that archive is to be the EROS Data Center in my home state, and I expect that EROS' talented scientists would be quite active in the research programs. But it is extremely important to our overall national policy that we maintain a strong scientific program. We have been moving too slowly in that area, and need to be more aggressive in maintaining our technological superiority in land remote sensing research and applications. This is another area I hope this Committee will look into, and leads into the second part of my statement concerning the long range goals of the Landsat program.

FUTURE DIRECTIONS

As much as I would like to believe otherwise, the Landsat program remains unviable as a going commercial concern. We have to quit playing with numbers and face this fact. The French cannot make a go of it without government support. Neither can we. This is evidenced in the substantial subsidy payments associated with the 1984 Commercialization Act. This is not to say it should not be commercialized or cannot be commercially viable in the future. And it certainly should not be interpreted as a justification for scrapping the Landsat program. Although I have been skeptical of commercialization, I have always strongly believed in the Landsat program.

The problem is that too many people have approached the issue with the blinders of commercial viability. The importance of the Landsat program goes well beyond its commercial or economic value. We need to look to it for its scientific and technological importance, as well. To the extent commercialization can lessen program costs to the government--great, I am all for it. But in weighing the program's future, we need to consider its tremendous scientific and technological contributions. It would be extremely short-sighted to scrap the program if it proves to be commercially unviable. We already have invested one and one-half billion dollars in pioneering the program and gaining the world-wide leadership we enjoy today. We already have sacrificed too much of that leadership by our indecision and perceived "non-support" for the program.

I cannot emphasize enough the technological and scientific importance of Landsat in understanding the planet on which we live. For example, the present and future Landsat data are key ingredients for performing Earth Systems Science study. This is an area in which NASA has become increasingly interested, and I applaud them for that. The maintenance of an historical archive, the acquisition of new data, and the technological and scientific advancements made in processing and analyzing these data are essential to the adequate study of earth, its systems, and its global processes. We are spending billions of dollars on four expeditions to our sister planets in this solar system, but we continue to neglect our own back yard of planet earth--which could yield information many times more valuable than that collected from Mars and other planets.

So we need to keep the scientific aspect of the program strong. We need to continue research and development efforts. We cannot forego its scientific and technological contributions simply because it cannot make it on its own in the marketplace. That is my primary message today. Let's quit looking at this issue with the blinders of commercialization and give greater recognition to Landsat's scientific and technological importance. A commercial entity cannot pick up that slack. Our commitment in this area must remain strong, and we need to let the world know the the United States is going to be in this business for the long term.

With that, Mr. Chairman, I will close my opening remarks and would be glad to answer any questions.

United States Senate
COMMITTEE ON COMMERCE, SCIENCE,
AND TRANSPORTATION
WASHINGTON, DC 20510-6125

March 13, 1987

The Honorable James C. Miller
Director
Office of Management and Budget
Washington, D.C. 20530

Dear Jim:

The purpose of this letter is to bring to your attention a potential problem related to the Fiscal Year 1988 budget request of the National Oceanic and Atmospheric Administration (NOAA). NOAA's FY 1988 budget request provides no funding to continue the operation of the Landsat-4 and -5 satellites or the archiving, processing, and distribution of data from these and previous Landsat satellites. We are told that the decision to omit these funds from the budget request was based on the fact that, since the nomimal three-year design life of Landsat-5 was scheduled to expire in March, 1987 no funds would be required to operate it in FY 1988.

Landsat-5 has, however, surpassed its nominal design life and, like Landsat-4, shows no apparent signs of expiring. In fact, if the life of previous Landsat satellites is any indicator, Landsat-4 and -5 should continue to operate into and through FY 1988.

The obvious conclusion from this is that Landsat-4 and -5 will require operational funds in FY 1988. Funding on the order of $30 million is necessary to ensure the continued acquisition of data, command and control of the spacecraft, and production and archiving of Landsat data, as mandated in Public Law 98-365, the "Land Remote-Sensing Commercialization Act of 1984."

While there remain several uncertainties associated with the commercialization of our land remote sensing satellite system, we should not allow these uncertainties to affect the maximum utilization of this important national asset. Over the years, we have made a significant investment to develop our nation's land remote sensing capabilities. These national capabilities should not be permitted to lie fallow. The scientific, technological, and economic benefits that are derived from the operation of the Landsat system are well documented. NOAA's FY 1988 budget request must be augmented to support the continued operation of Landsat-4 and -5 if our nation expects to continue to benefit from this significant investment and these important capabilities.

We would be pleased to discuss this matter with you at a later date. We appreciate your consideration and cooperation in the resolution of this issue.

Sincerely,

Larry Pressler
Larry Pressler
Ranking Republican Member,
Subcommittee on Science,
Technology, and Space

Don Riegle
Donald W. Riegle, Jr.
Chairman,
Subcommittee on Science,
Technology, and Space

ERNEST F. HOLLINGS, SOUTH CAROLINA, CHAIRMAN

DANIEL K. INOUYE, HAWAII
WENDELL H. FORD, KENTUCKY
DONALD W. RIEGLE, JR., MICHIGAN
J. JAMES EXON, NEBRASKA
ALBERT GORE, JR., TENNESSEE
JOHN D. ROCKEFELLER IV, WEST VIRGINIA
LLOYD BENTSEN, TEXAS
JOHN F. KERRY, MASSACHUSETTS
JOHN B. BREAUX, LOUISIANA
BROCK ADAMS, WASHINGTON

JOHN C. DANFORTH, MISSOURI
BOB PACKWOOD, OREGON
NANCY LANDON KASSEBAUM, KANSAS
LARRY PRESSLER, SOUTH DAKOTA
TED STEVENS, ALASKA
BOB KASTEN, WISCONSIN
PAUL S. TRIBLE, JR., VIRGINIA
PETE WILSON, CALIFORNIA
JOHN McCAIN, ARIZONA

RALPH B. EVERETT, CHIEF COUNSEL AND STAFF DIRECTOR
W. ALLEN MOORE, MINORITY CHIEF OF STAFF

United States Senate
COMMITTEE ON COMMERCE, SCIENCE,
AND TRANSPORTATION
WASHINGTON, DC 20510-6125

March 13, 1987

The Honorable Malcolm Baldrige
Secretary of Commerce
Department of Commerce
Washington, D.C. 20230

Dear Mac:

You are aware, of course, that NOAA's Fiscal Year 1988 budget request provides no funding to continue the operation of the Landsat-4 and -5 satellites or the archiving, processing, and distribution of data from these and previous Landsat satellites. We are told that the decision to omit these funds from the budget request was based on the fact that, since the nomimal three-year design life of Landsat-5 was scheduled to expire in March, 1987 no funds would be required to operate it in FY 1988.

Landsat-5 has, however, surpassed its nominal design life and, like Landsat-4, shows no apparent signs of expiring. In fact, if the life of previous Landsat satellites is any indicator, Landsat-4 and -5 should continue to operate into and through FY 1988.

The obvious conclusion from this is that Landsat-4 and -5 will require operational funds in FY 1988. Funding on the order of $30 million should be sufficient to ensure the continued acquisition of data, command and control of the spacecraft, and production and archiving of Landsat data, as mandated in Public Law 98-365, the "Land Remote-Sensing Commercialization Act of 1984."

While there remain several uncertainties associated with the commercialization of our land remote sensing satellite system, we should not allow these uncertainties to affect the maximum utilization of this important national asset. Over the years, we have made a significant investment to develop our nation's land remote sensing capabilities. These national capabilities should not be permitted to lie fallow. The scientific, technological, and economic benefits that are derived from the operation of the Landsat system are well documented. We urge you to submit a budget amendment to

The Honorable Malcolm Baldrige
March 13, 1987
Page two

augment NOAA's FY 1988 budget request for the continued operation of Landsat-4 and -5 to ensure that our nation continues to benefit from this significant investment and these important capabilities.

We would be pleased to discuss this matter with you at a later date. We appreciate your consideration and cooperation in the resolution of this issue.

Sincerely,

Larry Pressler

Larry Pressler
Ranking Republican Member,
Subcommittee on Science,
Technology, and Space

Don Riegle

Donald W. Riegle, Jr.
Chairman,
Subcommittee on Science,
Technology, and Space

Mr. SCHEUER. Thank you very much, Senator.

Your words and your views are really very much in agreement with ours. I have no questions to ask you. I agree with everything you said.

Miss Schneider.

Miss SCHNEIDER. I have no questions.

Mr. SCHEUER. George Brown.

Mr. GEORGE BROWN. No questions.

Senator PRESSLER. If only my constituents were so kind. Thank you.

Mr. SCHEUER. Congressman Clarence J. Brown, Deputy Secretary of the Department of Commerce. Bud, It's a great pleasure to have you here. We welcome your associate, Tony Calio, whom we have heard from many times and who has a great deal of credibility with this Committee.

We especially welcome you as a former colleague. We have come to know and respect your high intelligence, good judgment, common sense and in addition, good humor.

Please be assured your prepared testimony will be printed in full in the record. Why you don't take 8 to 10 minutes and chat with us informally and then we will have some questions for you.

STATEMENT OF CLARENCE J. BROWN, DEPUTY SECRETARY OF COMMERCE, DEPARTMENT OF COMMERCE, ACCOMPANIED BY ANTHONY J. CALIO, NOAA ADMINISTRATOR

Mr. CLARENCE BROWN. Mr. Chairman, thank you very much. First, let me commend you and the other members of this Committee for having this hearing because it is an issue of importance and it is one which has to be resolved, certainly during this budget cycle in one way or another.

I want to open, if I may, with just a couple of parts of my testimony as prepared so as to emphasize the situation in which we find ourselves. They have been explored to some extent already with OMB, but I think we can state them somewhat more succinctly and clearly.

Four major items have affected the effort over the past year to resolve the problems of the operation of Landsat. First, there is an unwillingness on the part of the private sector data users and EOSAT to share financing the program in a way adequate for us to meet that obligation source. The increasing pressure on the budget associated with the Gramm-Rudman-Hollings Act has been a factor in the determinations of OMB, our Department and the Congress.

There have been increased costs associated with the loss of one type of launching capability as a result of the Challenger disaster and finally, we have an increasing competitive situation in the world that is moving along quite rapidly also.

In September of 1985, the Department of Commerce signed a contract with EOSAT for that organization to operate the Landsat program and support it commercially. This contract provided that EOSAT would design and build 2 TIROS-based satellites and a new ground system at a cost of $250 million. The government would provide two launches in 1988 and 1992 each. During the past 18 months, EOSAT has been operating the Landsat-4/5 system and marketing the Landsat data.

Two changes in the spacecraft hardware for Landsat 6 and 7 were made in the contract in March of 1986. The negotiation for those changes began in November of 1985 and they were completed right after the shuttle disaster and at that point we did not know the full impact of the shuttle disaster.

First, we changed the launch vehicle from the originally planned Titan II to the shuttle, in order to accommodate the congressional desire that launches be conducted using the NASA Space Transportation System to the maximum extent possible.

Secondly, EOSAT requested that we allow them to change from the planned TIROS-type of spacecraft to a repairable in-orbit 20 year life time space platform known as OMNISTAR. This change was proposed by EOSAT with the stipulation that it would be at no additional cost to the government. EOSAT felt that this change would improve their long term likelihood of commercial success by both reducing their capital expenditures for spacecraft and by providing additional opportunities for revenue.

We evaluated the EOSAT request using an independent panel of specialists, predominantly from outside the Department, the government, and concluded that as long as EOSAT and its partners covered all additional costs associated with the transition to OMNISTAR, NOAA had no opposition to change.

We have been told that EOSAT began designing and developing the OMNISTAR spacecraft in early 1986.

Two events then required us to consider other changes in the EOSAT contract. Both of these occurred in fiscal year 1986. First, the cost increase associated with the Challenger disaster just over a year ago and secondly, the Administration's decision to eliminate further funding for Landsat development which became evident in the fiscal year 1988 budget submission in January 1987.

We had an indication of that also in the 1986 budget submission, that is January of 1986 budget submission for fiscal year 1987, but the 1988 budget reconfirmed that position on the part of the Administration.

With that, the costs have—with those circumstances occurring, the costs have outstripped our capacity to provide method of launching.

During the preparation of the President's fiscal year 1987 budget request, it became clear to the Administration that in recognition that the program primarily represents private interests and to meet both the President's desire to reduce the Federal deficit and to respond to the Gramm-Rudman-Hollings Act, government funding for Landsat 6 and 7 could not be provided beyond the $125 million already appropriated.

Instead, all additional investments would have to come from the EOSAT revenues or other government and private sector sources.

During the past year, we have evaluated several Landsat strategies with the intent of limiting government funding for EOSAT. Since the shuttle will not be available for launch from the Western Test Range until 1992 at the very earliest, it was obvious that we would have to find and fund an alternative launch capacity as well and this has implications concerning the Omnistar proposal.

Therefore, we have concentrated on strategies which would provide for a Landsat spacecraft to be launched as soon as possible on a conventional, now available, expendable launch vehicle. We have proposed that Landsat 6, the next Landsat be a TIROS-based spacecraft, that it be launched on a Titan II launch vehicle. Two very important points must be made here. First, successful commercialization will require a continuous line of spacecraft, as indicated in the letter I sent to OMB, and we wanted them to know that and not make a decision without that thought in mind, not just one spacecraft, but two. Second, the government cannot continue to fund these if our aim really is commercialization. In other words, if it is really going to be picked up by the private sector.

We forwarded the plan on October 24, 1986 for a one satellite system providing $209.2 million plus $50 million for one launch as we were required to do by the fiscal year 1987 continuing resolution. This plan would be supported by $27.5 million earmarked for Landsat included in the Department of Commerce fiscal year 1987 continuing resolution, plus $35 million reprogrammed from Polar Spacecraft and Launching.

The Senate Appropriations Committee disapproved this plan, stating that it would not result in commercialization without an Administration commitment to a second satellite and additional subsidies. An additional satellite may be needed but should not be funded by additional government subsidies, they suggested.

On February 18, 1987, EOSAT proposed a revised program to the Department. This program provides for 2 TIROS-based satellites and a new ground system, essentially the same as in the original contract, at a total cost of $366.8 million, of which $90 million is roughly what they have already spent on the contract. Two Titan II launches would be needed and based on informal discussions with the Air Force officials, we think that would cost an additional $70 million as a part of that total of $366.8 million.

Mr. Chairman, we are considering several alternatives to proceed with Landsat commercialization. One involves an orbit serviceable—an on-orbit serviceable platform known as Omnistar, which could increase the chances of commercial success of Landsat, we believe. A decision to move on such a platform, however, has to be based on market considerations by the contractor and not decided by the government. If the contractor believes that the benefits outweigh the considerable increase in costs and if they are willing to pay them, then I believe we would have no opposition to an additional Landsat-7 or 8 of an Omnistar design.

The concern I have with Omnistar is based on the launch problem. It must be launched on the shuttle or on a Titan IV from the Western Test Range. The shuttle will not be available until 1992 and that date is very uncertain and could slip further. Titan IV is extremely expensive. The cost estimate for a Titan IV launch quoted to the Department last year was $170 million. The current estimate for a Titan IV launch is it has risen to well over $200 million. So the Omnistar only—since the Omnistar only needs half the capacity of the Titan IV, it is difficult to find a partner, however, and we are not sure what that launch cost ultimately may be.

I think that summarizes the history and our current position on the situation. We would be happy to try to respond to your questions, Mr. Chairman.

[The prepared statement and attached letter of Mr. Clarence J. Brown follows:]

TESTIMONY
OF
CLARENCE BROWN
DEPUTY SECRETARY
U.S. DEPARTMENT OF COMMERCE

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH
AND ENVIRONMENT
AND THE
SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

MARCH 31, 1987

Mr. Chairmen and Members of the Subcommittees:

I appreciate this opportunity to appear before you today to discuss Landsat commercialization and our plans to obligate the FY 87 funding contained in the Continuing Resolution under the current Department of Commerce (DOC) commercialization contract with the Earth Observation Satellite (EOSAT) Corporation. Four major items have affected this effort over the past year: unwillingness of private-sector data users and EOSAT to share in the financing of the program; the increasing pressure on the budget associated with the Gramm-Rudman-Hollings Act; increased costs associated with the loss of one type of launch capability due to the Challenger disaster; and, the competitive situation in the world.

SUMMARY OF STATUS OF COMMERCIALIZATION

In September 1985, the Department of Commerce signed a contract with EOSAT for that organization to operate the Landsat program and support it commercially. This contract provided that

EOSAT would design and build two TIROS-based satellites and a new ground system at a cost of $250 million. The Government would provide two launches, in 1988 and 1992. During the past eighteen months, EOSAT has been operating the Landsat 4/5 system and marketing the Landsat data.

Two changes in the spacecraft hardware for Landsat 6 and 7 were made in the contract in March of 1986. We changed the launch vehicle from the originally planned Titan II to the Shuttle in order to accommodate the Congressional desire that launches be conducted using the NASA Space Transportation System to the maximum extent possible. Second, EOSAT requested that we allow them to change from the planned TIROS-type of spacecraft to a repairable in-orbit 20-year lifetime space platform known as Omnistar. This change was proposed by EOSAT with the stipulation that it would be at no additional cost to the Government. EOSAT felt that this change would improve their long-term likelihood of commercial success by both reducing their capital expenditures for spacecraft and by providing additional opportunities for revenue.

The National Oceanic and Atmospheric Administration (NOAA) carefully evaluated this EOSAT request, using an independent panel made up of specialists predominantly outside the Government. NOAA concluded that as long as EOSAT and its partners covered all additional costs associated with the transition to Omnistar, NOAA had no opposition to the change. We have been told that EOSAT began designing and developing the Omnistar spacecraft in early 1986.

Two events in FY 86, required us to consider other changes in the EOSAT contract: first, cost increases associated with the Challenger disaster just over a year ago; and second, the Administration's decision to eliminate further funding for Landsat development which became evident in the FY ~~88~~ 87 budget submission in January, 1987.

During the preparation of the President's FY 87 budget request, it became clear to the Administration that, to meet both the President's desire to reduce the Federal deficit and to respond to the Gramm-Rudman-Hollings Act, and in recognition that the program primarily represents private interests, Government funding for Landsats 6 and 7 could not be provided beyond the $125 million already appropriated. Instead, all additional investment would have to come from EOSAT revenues or other Government and private-sector sources.

During the past year, we have evaluated several Landsat strategies, with the intent of limiting Government funding for EOSAT. Since the Shuttle will not be available for launch from the Western Test Range until 1992 at the earliest, it was obvious that we would have to find and fund an alternative launch capability as well and this has implications concerning the Omnistar proposals.

Therefore, we have concentrated on strategies which would provide for a Landsat spacecraft to be launched as soon as possible on a conventional (now available) expendable launch vehicle. We have proposed that Landsat 6 (the next Landsat) be a TIROS-based spacecraft, and that it be launched on a Titan II launch vehicle. Two very important points must be made here: first, successful commercialization will require a continuous line of spacecraft, not just one spacecraft or two; and second, the Government cannot continue to fund these, if our aim really is commercialization.

PROPOSED CONTRACTS AND BUDGET

On October 24, 1986, the Department forwarded a plan to the Congress for a one-satellite system, providing $209.2 million plus $50 million for one launch as we were required to do by the FY 87 Continuing Resolution. This plan would be supported by the $27.5 million earmarked for Landsat included in the DOC FY 87 Continuing Resolution plus $35 million reprogrammed from Polar Spacecraft and Launching. Use of these funds in FY 87 will not affect NOAA's ability to maintain the polar program specified by Congress in the FY 87 Continuing Resolution, i.e., one that will "minimize the risk of a data gap, provide a backup satellite in orbit, and provide future launches as required to maintain this guidance".

The Senate Appropriations Committee disapproved this plan, stating that it would not result in commercialization without an Administration commitment to a second satellite and additional subsidies. An additional satellite may be needed but should not be funded by additional Government subsidies.

On February 18, 1987, EOSAT proposed a revised program to the Department. This program provides for two TIROS-based satellites and a new ground system, essentially the same as in the original contract, at a total cost of $366.8 million. The satellites would be launched on Titan II's eighteen months later than the original launch dates. Their estimate of the cost of the two TIROS-type spacecraft, and a new ground system is $296.8 million. This amount includes the $90 million that they have already spent on the contract. Two Titan II launches would be needed and based on informal discussions with Air Force officials, would cost an additional $70 million.

Mr. Chairman we are considering several alternatives to proceed with Landsat commercialization. One involves an on-orbit serviceable platform known as "Omnistar" which could increase the chance of the commercial success of Landsat. A decision to move to such a platform, however, should be based on market considerations by the contractor, and not the Government. If the contractor believes that the benefits outweigh the considerable increase in costs and are willing to pay them, then I believe we would have no opposition to an additional Landsat 7 or 8 of an Omnistar design. The concern I have with Omnistar is based on the launch problem: it must be launched on the Shuttle or on a Titan IV from the Western Test Range. The Shuttle will not be available for a polar orbit launch until late 1992, and that date is very uncertain and could slip considerably. The Titan IV is extremely expensive. The cost estimate for a Titan IV launch quoted to the Department last year was $170 million. Current estimates for a Titan IV launch have risen well over $200 million. The Omnistar only needs half the capacity of a Titan IV, but it is difficult to find a partner to share the launch.

The Department has proceeded with implementing Title IV of P.L. 98-365 which requires the Department to issue licensing regulations. This requires no funding.

LICENSING REGULATIONS

The Department has forwarded the final licensing regulations to OMB for final clearance. These final regulations are not significantly different from the proposed regulations. Both assert the "Minimum practical" oversight as directed by the Act, setting forth procedures for complying with the Act's requirements rather than adding to these requirements. The procedures establish a flexible, case-by-case review of each license application to accommodate the specific needs of the applicant. With rapidly changing technology in this field, the regulations will be reviewed periodically to ensure that they do not inadvertently preclude new commercial opportunities.

The regulations reflect the importance which the Department places on developing a commercial remote-sensing industry while adequately protecting basic U.S. interests -- non-discriminatory access to the unenhanced data, national security, and international obligations. I am confident that our regulatory approach will promote the industry and encourage widespread use of remote-sensing, including its use for news gathering purposes.

CONCLUSION

In closing, I would like to say the Government has already made over a $1 billion investment in Landsat. The Administration believes that the private sector which reaps the primary benefits of Landsat should assume a greater role in financing the program.

Thank you for this opportunity to present a status report on the Landsat commercialization effort.

THE DEPUTY SECRETARY OF COMMER
Washington, DC 20230

March 4, 1987

Honorable Joseph R. Wright, Jr.
Deputy Director
Office of Management and Budget
Washington, D.C. 20503

Dear Joe,

In September 1985, the Department of Commerce signed a contract with the Earth Observation Satellite Company (EOSAT) for commercialization of the Landsat program. This contract provided that EOSAT would design and build two TIROS-based satellites and a new ground system at a cost of $250 million. The Government would provide two launches, in 1988 and 1992. The contract was subsequently modified at the request of EOSAT to permit them to develop two Omnistar space platforms instead of TIROS-based satellites, at no additional cost to the Government.

During FY 86, two events required us to consider changing the EOSAT contract: the Challenger disaster and the OMB decision to eliminate further funding for Landsat development. In October 1986, the Department submitted to OMB a revised Landsat commercialization plan. It provided for two satellites, a TIROS-based spacecraft followed by an Omnistar space platform, and a new ground system, with an estimated cost of $316 million plus the cost of two launches. We believed this plan to be more commercially viable than the original contract, due to the benefits of the Omnistar platform.

OMB responded by approving a plan for a one-satellite system, providing $209.2 million plus $50 million for one launch. The Department forwarded this plan to the Congress, as we were required to do by the FY 87 Continuing Resolution. The Senate Appropriations Committee disapproved this plan, stating that it would not result in commercialization without an Administration commitment to a second satellite and additional subsidies. The Department concurs with the Senate conclusion concerning commercial viability.

On February 18, 1987, EOSAT proposed a revised program to the Department. This program provides for two TIROS-based satellites and a new ground system, essentially the same as in the original contract, at a cost of $296.8 million plus $70 million for two launches. The satellites would be launched on Titan II's eighteen months later than the original launch dates. This proposal is as commercially viable as the original contract.

The estimated cost of $70 million for two Titan launches is based on NOAA discussions with the Air Force. It is a verbal agreement. The FY 88 budget's estimate of $50 million for one launch was based on written confirmation from the Air Force. Consequently, the commitment and cost estimate in the new proposal are less certain.

Since the OMB one-satellite plan has been disapproved by the Senate, and Commerce has no available resources for Landsat commercialization beyond those identified in the President's budget, we must turn to OMB for guidance. We believe there are only two options: prepare a new two-satellite plan for Congressional consideration or terminate the Landsat commercialization program. The Department recommends development of a plan based on EOSAT's February 18 proposal.

We request OMB's approval of this recommendation. This option requires that OMB increase the Department's planning ceiling for FY 89 - FY 92 by a total of $107.6 million. The launch date for Landsat 6 slips nine months from last year's EOSAT proposal, from December 1989 to September 1990. While we think Landsat 5 is likely to continue operating for at least another year, the slippage increases the potential length of a data gap. In addition, funds were not requested for operation of Landsats 4 and 5, as both systems would have outlived their design lives by mid-FY 1987. Should they continue to operate beyond that point, an additional $25-30 million would be required for operations.

Should OMB decide not to approve this proposal (and thus effectively terminate the program), the Department will have no alternative but to terminate the contract with EOSAT.

Sincerely,

Clarence J. Brown

Mr. SCHEUER. Thank you very much, Bud.

Bud, in your letter of March 4th to Joe Wright, you said in the second paragraph, after rehearsing it in the first paragraph, that the Department of Commerce signed a contract with EOSAT. You say in the second paragraph, two events required us to consider changing the EOSAT contract, first, the Challenger disaster which delayed everything a year and a half or two years, and then second, the OMB decision to eliminate further funding for Landsat development.

In other words, you are saying that because the government has repudiated its contract with EOSAT, we have to consider changing the contract with EOSAT. I don't quite understand what you are saying there.

Mr. CLARENCE BROWN. Well, in effect, Mr. Chairman, the law requires commercialization and that also requires 2 Landsat birds in the air. The Senate drew our attention to the fact that the one Landsat proposal therefore was not in their opinion in accordance with the requirements for commercialization.

Mr. SCHEUER. What I'm asking you, Bud, is, how do you justify OMB's decision simply to walk away from the contract?

Mr. CLARENCE BROWN. Well, I'm not sure I would characterize it quite in that way. OMB has said to us——

Mr. SCHEUER. What you are saying is you had to consider changing the contract because OMB on behalf of our government, repudiated the contract. Is that a fair statement?

Mr. CLARENCE BROWN. I think that's a fair statement.

Mr. SCHEUER. Do you feel that kind of conduct is best conceived to encourage the private sector to engage in long term joint efforts with the government in developing something as unpredictable and subject to the vagaries of chance, accident, change, as this incredibly sophisticated high tech space enterprise?

Mr. CLARENCE BROWN. Well, all of us work under a variety of pressures, Mr. Chairman, and I think what was motivating OMB in this circumstance was (a) the requirement for getting a bird in the air, to continue Landsat in operation at all; and (b) the pressures of the budget on OMB and trying to determine where that money was going to come from.

Mr. SCHEUER. Yes, and in your testimony, you talk about four major items. You picked up a couple of extra major items, from two to four and very properly so, and you talk about one of the major items being increased pressure on the budget associated with Gramm-Rudman, and increased costs connected with the loss of one type of launch capability as a result of the Challenger, and the competitive situation in the world.

Do you feel that if the private enterprise feels that the government, due to any of these vagaries, budget pressure, world competition, an accident, a setback, is going to feel justified in repudiating a contract, that is going to strengthen the resolve of the private sector to enter into these very chancy, extremely esoteric and hard to pin down costs of these long term, decade long space development efforts?

Mr. CLARENCE BROWN. Mr. Chairman, you referred to the cost of the Defense Department of toilet seats and hammers, and my guess is that in some respects maybe the private sector writes some of those added costs into their contracts with the Federal Government for specifically the reason you mentioned, the vagaries of dealing with the Federal Government from time to time.

Mr. SCHEUER. Right. What's the private sector going to feel when they sign a contract that presumably they will have to live up to, and when they see that the government, because of the loop hole, because of the escape hatch they are given in living up to a 10 year contract, through the loop hole of one year funding, that if the private enterprise feels that the government due to increased budget pressures, their perception of the international competitive situation in the world, or an accident here——

Mr. CLARENCE BROWN. The shuttle disaster which was fairly cataclysmic for all of us.

Mr. SCHEUER. How is the private sector going to react? You are convinced there is a private sector role here and so am I. But, you know, that is based on the inviolability of contracts, unless there is some major breach. If the private sector feels that government can walk away from it due to these budget pressures and the politics of that, international competitiveness, as that changes from year to year, how is the private sector going to be able to make any investment, much less the investment on the order of magnitude you are talking about?

Mr. CLARENCE BROWN. Mr. Chairman, it is a problem. I think it is a question that perhaps would be better addressed to the private sector.

Mr. SCHEUER. No. I think the private sector wants the government to address it. The private sector had a contract. EOSAT has a contract. Hughes has a contract with EOSAT. Now, I'll admit, I wonder why Hughes isn't willing to pay more of the costs. Hughes is owned by General Motors. General Motors was apparently willing to pay H. Ross Perot $700 million just to get lost and not bother them at their Board meetings any more. It seems to me a small fraction of that injected into EOSAT might very well solve our problem, a third or a quarter or a fifth of that amount.

That's neither here nor there. They were living up to their contractual obligations. I would think they would expect the government to.

I don't want to belabor this but it seems to me either we have a modus operandi, an M.O. between government and the private sector to move forward together in a joint venture in space in which over a 10 year period or so, where each can rely on the integrity and the bonafides of the other or we don't, and then we ought to drop the concept of a joint venture.

Mr. CLARENCE BROWN. Mr. Chairman, I suggest that your question might better be addressed—if you want me to give you my opinion of what the viewpoint of the private sector is, I can do that, but I don't think it's worth a great deal, and if you want me to give you my opinion of what OMB had in its mind when it set the limit on the amount of money that could be spent, I can try to do that, too.

I'm not the best competent witness in either one of those cases. You have asked that question of the Office of Management and Budget and their answer has to be left on the record, I guess. I can't help you with their point nor can I help you with the private sector's viewpoint.

Mr. **Scheuer**. Congressman Ralph Hall, my co-chairman.

Mr. **Hall**. Thank you. Japan and probably other nations don't seem to be viewing commercialization being too affected by the bottom line or they are not holding them to the lick log of being a profit making thrust as a goal of remote sensing. I think the Japanese appear to intend to use remote sensing as a tool in addressing and developing global resources.

What's your feeling on that? First, do you agree with the assessment, that's Japan's approach to it?

Mr. **Clarence Brown**. Well, I think it is also our approach. The bottom line of profit making in either the 1 or 2 satellite approach or in the Omnistar approach, would provide for expenditures for the Federal Government in excess of the return being realized by EOSAT at this point.

Mr. **Hall**. Senator Pressler down played that, too, in my opinion.

Mr. **Clarence Brown**. I'm sorry. I don't understand.

Mr. **Hall**. The importance of making a profit.

Mr. **Clarence Brown**. Well, I'm trying to answer what I understood the question to be and that is under either a 1 Landsat or 2 Landsat or an Omnistar approach, the Federal Government would be subsidizing the operation of our remote sensing activity beyond the income that EOSAT would be recognizing from that operation. So, that is the approach of this government also.

Mr. **Hall**. What about the United States just abandoning the land remote sensing and simply buying data from France and Japan? I don't know what the State Department would tell you about that. What would be your feelings? Would you be comfortable with that?

Mr. **Clarence Brown**. If you are asking me for my personal feelings, remember, you are speaking to someone who was around in 1941, so I'm not too comfortable with that; no.

Mr. **Hall**. I think I will let others ask questions. Thank you.

Mr. **Scheuer**. Forgetting about 1941, that unhappy four or five-year period, and looking at it from today's competitive economics, do you feel it beyond the realm of possibility that the Japanese and the French, too, who were our allies during World War Two, might say this information is not available to you at any price, we are going to merchandise this information to the developing world, to mining and resource consortiums; if you want to get up there and compete, fine, but we are not giving this information to the United States, we are selling it to commercial users where and as we see fit?

Mr. **Hall**. And, Mr. Chairman, they are clearly developing that information with the subsidy money that they don't have to spend on their own defense.

Mr. **Scheuer**. That's right. But would that be a reasonable position for them? Would it be beyond the realm of imagination for us to believe that this information would not be available to us under any terms; that they might just take the position: we are going to merchandise it, we are going to sell it ourselves, we are not going to make it available to the United States?

Mr. CLARENCE BROWN. I would assume that if it is commercially available throughout the world, it would be available to those in the United States who would wish to buy it. I would hate to concede that we can't do it as successfully as they can, however.

Mr. SCHEUER. You would concede that——

Mr. CLARENCE BROWN. I would hate to concede that we in the United States can't do it as successfully as they can.

Mr. SCHEUER. Assume that economically, if you looked at it just from the point of cold, hard economics, that the cheapest way for us to get that information, assuming it were available, was to contract with the French and the Japanese. As a matter of our national security, as a matter of our national ethos, do you feel that there are other compelling reasons for us to go ahead and do it on our own even at somewhat additional cost?

Mr. CLARENCE BROWN. Mr. Chairman, when you get into the security area, you are getting into an area with which I am not familiar, and you have members of the committee who are. The question was interestingly raised as to whether or not, if we abandon this now, somebody at some point is going to want to get into it from the national security standpoint. My guess is that there is enough usage for this both in the private sector and in the national security sector to make the continuation of the project worthwhile.

I think the question was also appropriately raised that——

Mr. SCHEUER. On a two-satellite basis.

Mr. CLARENCE BROWN. If you will let me finish, Mr. Chairman. I think the question was also appropriately raised whether it ought to be done on a one-satellite, two-satellite or deferred until we get to the Omnistar basis, and those are the questions that I think this committee has to address and give the administration some advice on.

Mr. SCHEUER. Before I pass along to Dave McCurdy, in your March 4th letter you concluded that a one-satellite program, that is, Landsat 6 only, will not lead to successful commercialization of remote sensor.

Mr. CLARENCE BROWN. It would be a space holder.

Mr. SCHEUER. It would be what?

Mr. CLARENCE BROWN. A space holder, a place holder for ultimate commercialization later on.

Mr. SCHEUER. Under a two-satellite system?

Mr. CLARENCE BROWN. Under a one-satellite system. I think that is what you asked originally, one satellite.

Mr. SCHEUER. Do you feel that a one-satellite system is a secure and assured route for us to take?

Mr. CLARENCE BROWN. It is a place holder, I said, Mr. Chairman. It keeps us there for the moment.

Mr. SCHEUER. OK.

Congressman Dave McCurdy.

Mr. MCCURDY. Thank you, Mr. Chairman.

I appreciate the Secretary testifying today. I would actually like to ask a question of Dr. Calio.

The concern I have, and I have expressed it earlier, is that we entered into an agreement some years back or we conceptualized an approach that this administration argued should be going commercial, and that has been some time, but during that time, technology doesn't stop. It is not static. It is fluid, it moves, there is always some progress, and we see some changes in the abilities of some of our competitors.

The question I really have is that under the existing contract, do you believe we have locked in, or under the present situation of the legislation in Congress and the actions, that we have, in effect, locked into some obsolescent technology or that the technology has passed us by?

Mr. CLARENCE BROWN. Let me try to respond, and then I will certainly turn it over to Dr. Calio to give a more technical response. I think that is precisely where this hearing is of such value. I think we have to decide which of the various proposals that have come to us now out of the EOSAT contract and its modifications is the best way for us to go at this point, bearing in mind the costs, bearing in mind what has happened to the Shuttle, bearing in mind the change of technology, all of which I mentioned in my formal testimony, and the willingness of the private sector to belly up to the bar from the standpoint of the assessment they have already made based on their experience of what the commercial prospects are.

I think we probably have some consideration of either renegotiating or recompeting, depending on what direction technologically you wish take at this point, or cancelling and starting over.

Mr. MCCURDY. Unfortunately, we are dealing with the government, as you are well aware, and government does not operate very quickly and does not change very quickly, and we are having a hard time, as indicated in this current crisis that we are in. If you start talking about renegotiating and recompeting and all that, then how much farther down the road does that place us?

When I talk about the obsolescence, I referred to earlier that you have this French SPOT system, you have got the Japanese now, and the technology that they are opting for, I am not sure it is that much more advanced. I am not sure it is even any more advanced. But what it is, we have the technology available today in the United States to do what they are doing; it is just that we are not keeping pace with either, one, the perceived demand, or that because of the way the government operates, we are two models behind.

The issue is where do we want to be, and is commercialization still a viable plan? Should we be turning this over eventually?

Mr. CLARENCE BROWN. First, Mr. McCurdy, I agree with you the government does tend to move slowly and sometimes exceeding small, like the mills of the gods, but at the same time, we have modified the contract a couple of times since it began. One of the proposals that has come out of EOSAT, partner in that contract, was the Omnistar proposal.

Mr. MCCURDY. Which made a lot of sense to some of us.

Mr. CLARENCE BROWN. Which looked as if it might be viable while you had the Shuttle. Now the question is do you want to go to the Omnistar proposal now, which might give you more opportunities to get data and thereby enhance the potential for commercial viability.

Mr. MCCURDY. Wasn't the key there, though, flexibility? Flexibility is what I am arguing for. If you had a platform such as that, you had the potential to upgrade and enhance without going back and building a new satellite every time and launching it.

Mr. CLARENCE BROWN. That is correct. It had a higher up-front cost than the satellite proposal that was initially undertaken.

Mr. MCCURDY. I have been jumping back and forth from an Intelligence Committee markup this morning in R&D in Armed Services down the hall downstairs, and that is why I am coming back and forth, but that argument is not unique, that there is greater up-front cost to make a savings down the road.

Mr. CLARENCE BROWN. I am not suggesting it is; I am trying to respond to some of the earlier questions about why the administration in light of Gramm-Rudman may have felt that that was not a desirable circumstance to have to address at this point in view of the fact that you are cutting the budget generally as a result, again, of a congressionally-passed mandate.

Mr. MCCURDY. Would you state, as succinctly as possible—and I apologize for being out, but I had those other marks—exactly what your position is today vis-a-vis Omnistar and vis-a-vis the contract? Where is it today, March 31st?

Mr. CLARENCE BROWN. You asked for Dr. Calio to express his opinion on the contract earlier, and I should let him speak to the contract lest I make an error in that regard since he was involved in the direct negotiation of the contract.

Mr. CALIO. On the question of where the contract is right now?

Mr. MCCURDY. Maybe we need a snapshot. Things keep changing up here. Where are we, exactly, today?

Mr. CALIO. We currently have a contract that has not been modified to go back to the TIROS N spacecraft. We have an Omnistar contract. We are ready for an engineering change request. We have several proposals in from EOSAT. When we have a clear indication as to what course of action we should take, then we will be prepared to sit down and negotiate and engineering change to that contract.

Mr. MCCURDY. For the second satellite?

Mr. CALIO. No. Well, we actually have two Omnistars right now. We still are operating under the March 1986 contractual change, which was putting the TIROS N's into Omnistars and putting them on the Shuttle.

Mr. MCCURDY. So the current contract calls for Omnistar?

Mr. CALIO. On the Shuttle, that is correct.

Mr. MCCURDY. On the Shuttle.

Mr. CALIO. We have several proposals on the table as to how we might——

Mr. MCCURDY. How you would modify that.

Mr. CALIO. Yes.

Mr. MCCURDY. And the problem with that is that with the unavailability of the Shuttle and the manifest and you are not sure you could get a space on it up through a certain time frame.

Mr. CLARENCE BROWN. At least 1992.

Mr. MCCURDY. And the Omnistar could be launched, however, by an ELV or some other system, but the difficulty would be the servicing; is that correct?

Mr. Calio. Correct. The high cost for the launch and the reservicing on orbit would require a Shuttle-type capability out of the western test range sometime in the early to mid-1990s——

Mr. Clarence Brown. Right.

Mr. McCurdy. And that is a major hurdle that we have to consider.

Mr. Calio. Right.

Mr. McCurdy. Now, with the contract on Omnistar right now, and you are asking for engineering changes, this would be a modification in the contract with the contractor, EOSAT, to what end? What do you see the end to be?

Mr. Calio. The notion under the Landsat Act was to provide six years of data acquisition. We would move back to that objective, and we would do that by changing the contract to include either one or two Titan-II launched TIROS-N spacecraft with an instrumentation to be defined pretty much by EOSAT.

Mr. McCurdy. The 6 would be fairly current technology similar to what 4 and 5 are providing?

Mr. Calio. Not exactly.

Mr. McCurdy. Some upgrade from that.

Mr. Calio. Yes.

Mr. McCurdy. Now, 7, since it is farther out, there is still some issue of definition of what technology would be available or provided.

Mr. Calio. And the cost. Getting back to your previous question, I would answer your previous question yes and no, and it passed us by. From the standpoint of new technologies, we have moved from old devices into solid state devices, older scanning devices into solid state devices. There was some research and development being done on that that had been terminated and would have been available to EOSAT in the future if that were to continue. That is no longer being done.

There is other research being carried out, technological development, for improved solid state scanners that are still on the technology development arena being developed. What would be available to EOSAT would be pretty much dependent on them, what fraction of that technology they wanted to be able to use based on their own costs, based on their own assessment of the marketplace and how much they could assess would be increased in that market share by the new technology, and the costs.

Mr. McCurdy. If I may at this point, let me clarify something. Now, if on the second satellite EOSAT were to come back and say according to our market studies or whatever, based on what the French and Japanese are doing, we want to improve our resolution, make it from 30 meters to some number, 15, 10, whatever, and that is the optical, and we want to look at—say they say they wanted to go with radar or something.

Now, under the contract that is existing, you have to renegotiate it anyway, or you have to have some modification—maybe not renegotiate, but you have to have some modification to move from Omnistar to some other ELV-launched satellite; correct? Who is responsible? What you are saying is that the ceiling on the contract is fixed and that any differences in the technology provided would be borne solely by the contractor?

Mr. **Calio**. If I would fall back to the original premise, the way we negotiated the original contract, which was two TIROS N's, Titan-II launched for $250 million, including a ground station, the technology development was entirely up to EOSAT, and what instruments they put on board, I believe there was a ceiling established on resolution. I'm not sure. We don't recall whether there was a performance spec on the data, but we would go back to that situation, and what we have moved to with this one proposal is relooking at it exactly the same way, going back to TIROS-N, Titan-II launched, with the instrument development and determination being up to EOSAT.

Mr. **McCurdy**. As of March 31st, what is the launch cost for two Titans?

Mr. **Calio**. Our best estimate right now in informal discussions with the Air Force is about $35 million.

Mr. **McCurdy**. About $35 million.

Now, do you, Dr. Calio, believe that two TIROS-N satellites can drive us to commercialization and be competitive in the future? Is it in the best interest of the United States to have two TIROS-N satellites?

Mr. **Clarence Brown**. I want to submit, if I may, Congressman, that that is a tough question for us to answer——

Mr. **McCurdy**. That is why I am asking the question, Secretary Brown.

Mr. **Clarence Brown** [continuing]. On the record in this forum, and it is precisely why I said that we may be in a position where we either have to renegotiate or recompete under the procurement laws. We are——

Mr. **McCurdy**. Let me rephrase it.

Mr. **Clarence Brown**. Can I finish my thought on this, if I may, please?

Mr. **McCurdy**. Yes, sir.

Mr. **Clarence Brown**. Because we are seeing the technology change, and obviously we are seeing competition in the picture, and if the competition moves faster than our capacity to change our technology, maybe we are not in the game, and on that hinges whether or not it is possible to commercialize Landsat viably. So it is a judgment that we can make based on the proposals and the possibilities.

It is why we went to the Omnistar in the negotiation from November of 1985 to March of 1986 and agreed to the Omnistar thrust in the contract, but unfortunately, the Shuttle disaster intervened, which made that null and void, in effect. It wasn't the government cancelling the contract or cancelling the obligation. We attempted to accommodate EOSAT in that regard, but the Shuttle made what we agreed to impossible from both sides.

So it is one of the risks when you are dealing on the edge of technology.

Mr. **McCurdy**. So what you are telling me, if I understand——

Mr. **Scheuer**. Will my colleague yield just very briefly?

Mr. **McCurdy**. Certainly.

Mr. **Scheuer**. It should be on the record that OMB cancelled the funding long before the Challenger accident. Let me ask you: just in the last 30 days have things changed? On March 4th you wrote the OMB that: We have only two options: prepare a new two-satellite plan or terminate the Landsat commercialization program. Should OMB decide not to approve this proposal and thus effectively terminate the program, and this proposal is a two-satellite proposal; if OMB should determine not to approve this proposal, the Department, that is the Department of Commerce, will have no alternative but to terminate the contract with EOSAT.

Now, this is less than 30 days ago. Do you stand by that statement?

Mr. CLARENCE BROWN. That statement was correct as of 30 days ago, Mr. Chairman, and it is also correct as of today presuming the budgeting situation is left as it is. That is our circumstance. Now, only two proposals, I think, is an interpolation of your own. I didn't suggest only two options. I think there are, as we——

Mr. SCHEUER. Excuse me, Mr. Secretary. Let me quote directly from——

Mr. CLARENCE BROWN. Where are you quoting from?

Mr. SCHEUER. The second paragraph on page 2 of your letter, the second full sentence. "We believe that there are only two options: prepare a new two-satellite plan for congressional consideration or terminate the Landsat commercialization program."

Mr. CLARENCE BROWN. Given the circumstances that existed at that time and that exist right now, unless there is a change in the budget consideration, that is correct.

Mr. SCHEUER. Do you stand on that statement?

Mr. CLARENCE BROWN. As of this moment and as of the time the letter was written, that is correct. As I said, the parameters of budget are the thing that control that, and the Senate and now, I understand, also the House viewpoint with reference to the one-satellite option, the one-Landsat option.

Mr. SCHEUER. But you just said that there are two options, a two-satellite plan or wipe out the program, get out of the business, abandon the business to the French and the Japanese.

Mr. CLARENCE BROWN. Unless, to go back to Mr. McCurdy's point, you are going to expend considerably more money and try to go to an Omnistar choice.

Mr. SCHEUER. That is still a two-satellite program.

Mr. CLARENCE BROWN. Well, yes, I guess technically that is correct, but it is a different kind of approach than you would have under this Landsat proposal. You mentioned the Japanese option. That is not one I considered when I wrote that letter, and I guess it is not one, as a personal matter, I would choose now; but that, again, is subject to the guidance of the Congress and the administration.

Mr. SCHEUER. So you believe at the present time we should either abandon the field or move ahead with the two-satellite system and get on with it, go for it.

Mr. CLARENCE BROWN. Since you have told us, that is the Congress has told us that the one satellite choice is not the choice———

Mr. SCHEUER. That's what you said.

Mr. CLARENCE BROWN. That's what they said. Remember, the predicate of the letter is that the Senate has——

Mr. SCHEUER. That's correct.

Mr. CLARENCE BROWN [continuing]. Has turned down the one-satellite choice.

Mr. SCHEUER. That's correct. So you believe at the present time, considering the environment here on Capital Hill, that we consider across party lines and across camera lines, the one-satellite theory to be totally unacceptable? You yourself say that the realities that we are must go—move ahead promptly, expeditiously with the two-satellite program, or face the fact that we must abandon the field to the French and the Japanese.

Mr. CLARENCE BROWN. Yes, sir.

Mr. SCHEUER. Okay. I yield back the balance of my time to Mr. McCurdy.

Mr. CLARENCE BROWN. Not quite the latter, Mr. Chairman. I said one—the two-satellite choice or none at this point.

Mr. SCHEUER. But that's all we can do at this point.

Mr. CLARENCE BROWN. It doesn't necessarily abandon the field to the Japanese or the French.

Mr. SCHEUER. Well, well——

Mr. CLARENCE BROWN. If you want to reenter it later on, if you want to reenter the field later on, at such time as you do, you have the budget potential to do that, it is probably going to be more costly at that point.

Mr. SCHEUER. It will be much more costly, and since we have already seen that EOSAT has closed down their entire marketing capability, the French and—you couldn't do a greater gift to the French and the Japanese in assuring their preeminence in this space economic race, let us say, than to give them a several year additional hiatus on top of what the Challenger accident already has cost, an additional competitive advantage, and have closed down our marketing capability so that they have a clear sweep of the field.

Mr. CLARENCE BROWN. Mr. Chairman, I am an administrator now—I used to be a member of Congress, as you pointed out, and I am constrained as an administrator between what I am obliged to do because of the budget provided by the Office of Management & Budget, and the limitations put on me by the Congress. And I stated the situation as I saw it from an administrative standpoint. Please, however, do not put in my mouth the suggestion that I feel we ought to abandon the field.

Mr. SCHEUER. As a policymaker—after all, you are Deputy Secretary, that's hardly a nuts-and-bolts——

Mr. CLARENCE BROWN. That's a management responsbility, Mr. Chairman. That's not necessarily the policymaking role in the Department. The policy is made by the Secretary and the line officers.

Mr. SCHEUER. I respect that.

Congressman McCurdy.

Mr. MCCURDY. Thank the Chairman.

Secretary Brown, I am trying to pin down as much as you can tell us as to what—where the contract is and what in the negotiations, what are the major hang-ups? What are the parameters? And I think you, in your discussion with the Chairman, outlined them generally. OMB has said you can only have so much money; Congress says we are not going to buy a one-satellite.

Now do you see—what options do you see within those parameters that can make this a viable option? Or should we change the parameters? Or how should we change the parameters? And maybe Dr. Calio as the—he was one of those that started LANDSAT and NASA, and he understands the technology, he understands the state of the competition, he's negotiated the contracts. You know, if you think the contractor needs to come forth with more money and carry a greater share of the load, then say it. But I want to find out where we say. What is the problem?

Mr. CLARENCE BROWN. It really is not up to us to say whether the contractor can come forward with more money.

Mr. MCCURDY. Or should he.

Mr. CLARENCE BROWN. The contract calls for that, calls for the contractor to—based on the two-satellite proposal, to come forward with the funding to get to where they want to go, based on the way that contract was originally written.

Now if they don't feel they can do that, then we have got a mutual problem.

Mr. MCCURDY. Well, I think we have mutual problems, but I'm trying to define the problems. And I have yet to get a clear definition of what that is and how you see the government and the business sector getting out of that now.

The question I have is how much flexibility within the given contract do you and the contractor have in redefining the nature of the satellite? You had an Omnistar, you had a Taurus, you had—what? You have some flexibility there.

Mr. CLARENCE BROWN. Let me give you another parameter of why we accepted the Omnistar proposal. We had a relatively fixed price for the shuttle launch of the Omnistar and for what was the servicing cost. Whether or not there was in that shuttle launch cost a subsidy factor that NASA was absorbing also is appropriate to this discussion; and whether or not when the shuttle comes back into play in 1992, it will go on an on-cost basis or a subsidized basis, and what that price will be, is very difficult for us to predict from our vantagepoint.

That will have an impact on whether or not at that point you could get Omnistar up at a cost that the contractor feels he can bear in the process.

Mr. MCCURDY. And in the original contract you actually had a price for the shuttle launch?

Mr. CLARENCE BROWN. We knew what the shuttle launch price was at that point. Not in the original contract, but when we modified before the *Challenger* accident——

Mr. MCCURDY. But the shuttle costs were part of the contract, is what you're telling me?

Mr. CLARENCE BROWN. No.

Mr. CALIO. No, it's separate, but we had a fixed agreement with NASA.

Mr. MCCURDY. Okay. So what you are telling me is that there is some flexibility on the launch costs; is that correct? That it's not tied to the contract?

Mr. CLARENCE BROWN. Yes, that's right. That's right. That's right. When you asked about flexibility, again I am constrained by what I am given as a budget to work with, but, yes, there is flexibility in the contract.

Mr. McCurdy. On the launch.

Mr. Clarence Brown. Yes.

Mr. McCurdy. So if we were to deem—and this is not you, but if we were to deem, if Congress were to deem that some agency of the United States government were to pick up the costs of the launch, whatever it would be—shuttle, ELV or what, Titan—that you could do that within the existing contract? Yes, or no?

Mr. Clarence Brown. Yes. Yes, that's correct.

Mr. McCurdy. Great. I've been trying to get that on the record. So you've got the launch costs there. Now within the existing contract you have a ceiling of what, $250 million? What's the number, Tony?

Mr. Calio. Right now I think it's 209, I think is the number we have within the—the original contract value was for $257 million. $257 million.

Mr. McCurdy. Okay. Now within that amount, you got the requirement for the satellites, and you have flexibility in the technology, and you can renegotiate that within certain limits, I assume?

Mr. Calio. The deliverables were two satellites in orbit. We were to provide the launch capability and a ground system for operation.

Mr. McCurdy. Right. And you didn't say what kind of satellites they had to be.

Mr. Clarence Brown. They were to provide the ground system. We were to provide the launch. I don't think your comment would be clear in the record about that modification.

Mr. McCurdy. Okay.

Mr. Clarence Brown. And let me just say that again, demonstrated by what we have done in the adjustment of contract is the willingness to go to the technology that is available in concert with the other side of the contract, the private side of the contract.

Mr. McCurdy. When was the contract first negotiated?

Mr. Calio. The very beginning?

Mr. McCurdy. Yes. What timeframe are we talking about here?

Mr. Clarence Brown. It was completed, I think, in September 1985, and it was modified in March 1986. The negotiation began—the negotiation to modify began in November 1985.

Mr. McCurdy. Okay. Now if——

Mr. Clarence Brown. Are you asking about the original negotiations?

Mr. McCurdy. Well, I was trying to get a timeframe here. Say September 1985, mid-1985 up till—we're almost mid or first quarter 1987.

Mr. Clarence Brown. Legislation was signed in 1984; that I can remember, mid 1984 or early April or April or May of 1984.

Mr. McCurdy. Okay. Now if the——

Mr. Clarence Brown. July of '84.

Mr. McCurdy. Mid '84. We're not too far from being mid 1987. We are talking a three-year timeframe here, and we still don't have six up, and we are still questioning whether or not seven is out there, and what type of system it is going to be. If the United States government—how much flexibility again do we have as far as the total cost? If the government were to say, the Congress were to say you now have 300 and some odd million dollars instead of the 250 that is in the contract, what does that do to you? You, Department of Commerce, NOAA.

Mr. CLARENCE BROWN. Excuse me, sir.

[Pause.]

Mr. CLARENCE BROWN. Well, let me try to answer the question we were on—we were discussing a slightly different subject, which may be where you are headed on the question.

We can't spend any money we don't get, and if the Congress decides in its wisdom that we should get so much money for the launch cost, and that sustains the Administration's support or gets a veto and it's overridden in all its processes that the Congress and the Administration go through before we know what we have got to spend, yes, we would be obliged to spend that money, and we would spend it on the most efficient technical means between EOSAT and NOAA, the government contractor side, of providing the data that Landsat can provide.

If we, to go back to our earlier conversation, were to opt for Omnistar at that point, and you had a tight launch of Omnistar, the problem would be how do you service it after you've got it launched? So——

Mr. MCCURDY. I'm asking a basic legal question, I guess.

Mr. CLARENCE BROWN. Okay.

Mr. MCCURDY. And the basic——

Mr. CLARENCE BROWN. The judgment of what would be done with that money, we think, is one that has to be thought out very carefully——

Mr. MCCURDY. If Congress said under Land—under the commercialization of Landsat, you're going to two satellites, and we may want the second satellite to be competitive with certain technologies available, and you are going to have 300 and some odd million dollars to do that; would you have to renegotiate a contract to perform that function from Congress? Would you have to start from scratch?

Mr. CLARENCE BROWN. Now you are in a legal area, and I'm not sure whether we are competent to answer that. We have recently had a little problem on another unrelated—not NOAA, but another Commerce contract related to computer acquisitions, and we are operating under the procurement law that the Congress passed a year and a half ago, and that procurement law has made procurement a great deal more complicated and the rights of people in the contract, people who do not get the contract, a great deal more aggressively pursued, if I can use that term of art. And so I am not sure I am competent to answer that question. You had better ask our—based on what we have just experienced with reference to another contract, you'd best ask our General Counsel that question, and he is not with us today.

Mr. MCCURDY. Mr. Chairman, I'd just like to—and I don't have any further questions, and I understand I took more than my allotted time, but I can see how we have been floating here, and it's going to be a difficult—either we're going to have to get all the gentlemen together in one room at one time, or we're going to have to spell it out specifically, but I don't—based on the testimony we have received this morning, I have yet to see the forms in the fog to get us out of this dilemma. And maybe through the second day's hearings, we will have a little more clarification, but up to this point I have yet to see it.

Mr. CLARENCE BROWN. Well, Mr. Chairman, may I respond to that for just a couple of minutes? I want to make clear, Mr. McCurdy, and also to you, Mr. Chairman and the other members of the committee, that the Congress—the Commerce Department has not been reluctant to negotiate with the contractor in any way on the technical capacity of the system. I think we have demonstrated that within a matter of a few months after signing the contract originally, negotiated with them to modify their approach from the present Landsat up to Omnistar.

Unfortunately, having done that—and that's where the contract stands at this moment—having done that, Omnistar is not technically viable because you can put it up there, but then you can't get back and forth to it, because we don't have the shuttle capacity to do that, and won't have for another four or five years at the best.

Nor have we been reluctant to submit to the Office of Management and Budget EOSAT's alternative proposal now for the two Landsat concept for some judgment on that economic issue. But that has, as the Congressman has wisely pointed out, technical aspects to it also that mean what do we do between now and Omnistar, if that's where we want to go? And we are somewhat stuck with that also. We have to wait to find out what that decision will be. We apparently had the exchange this morning with OMB on that subject, and got some indication that that might be decided within a couple of weeks. But we must wait for that judgment because we can't spend money on this issue that we don't have, nor can we negotiate any modification of the contract with EOSAT without some reasonable understanding that the money would be available to meet the obligation.

So if that helps you see the forms in the fog, let me just say that the Commerce Department is not in any way delaying the issue. The explosion of the shuttle and a few other things had impacts on this that we had no control over.

Mr. SCHEUER. Well, if it were—I have to say——

Mr. CLARENCE BROWN. Mr. Calio wants to make one clarifying comment, so if I have made a misstatement, he will correct it, I am sure.

Mr. CALIO. No, it's not a misstatement. I really want to bring up one very important fact. When we transferred or modified the original contract in March of 1986 to Omnistar, it was no increase in cost to the government and no increase in schedule. It was a change in performance, but based on our technical evaluation from inside and outside of NOAA, from experts that assessed the proposal, that we came to the conclusion there were no additional risks in the current program we had on contract, EOSAT was willing to pick up any of the additional costs, and we were committed to make the original schedule. And we therefore concluded a change to the contract that no longer exists today from the standpoint of so many unknowns, and we already have a schedule impact. So from a project manager's standpoint, I would say we would have to compete the contract again, if we got into the mode that you were talking about for an undefined spacecraft.

Mr. Clarence Brown. We are not looking for villains in the piece in terms of EOSAT or OMB or the Congress or anyone else. But each of these elements have had some change in circumstance, and as you point out, the competition is changing in the process. I have also made that point in my testimony, and obviously as time runs, costs change, too. So it is in that three years a moving hammock on which we find ourselves.

Mr. McCurdy. I thank the gentleman for yielding.

Mr. Scheuer. I must confess that if the only intervening happening was the Challenger accident, and everybody else had stuck to their guns, the EOSAT/government contract would continue, and we would be on our way to a two-satellite program.

Mr. Clarence Brown. No, sir, Mr. Chairman, it would have to—well, to the two-satellite program, but it would have—it had been rewritten as of almost a month after the Challenger disaster because the negotiation started three months before the Challenger disaster, to be an Omnistar approach. We would still have to renegotiate with EOSAT to get that back to a two-conventional Landsat approach, and that does have some impact on the viability of the commercialization, because they saw Omnistar as a much more attractive method to commercialize.

In other words, something that would be more viable from their standpoint, and that's why we accommodated that change.

Mr. Scheuer. But having accommodated the change——

Mr. Clarence Brown. We'd have to accommodate another change now to back away from that, and that relates to your question about viability. That's a judgment for EOSAT to make, not one for us to make, if they think it's going to be viable under the two-satellite proposal, and they apparently have said it—that they think it will be, because they asked us to look at the two-conventional Landsat system. I don't know what——

Mr. Scheuer. Well, if they want to go ahead on a two-satellite proposal, and you think it's consistent with all of the arrangements, the contracts, and the policy, and the only exception has been the delay of what, a year or 18 months caused by the Challenger accident, why aren't we going ahead with the two——

Mr. Clarence Brown. It must be consistent with the basic elements of the contract, too, that the costs not change.

Mr. Scheuer. Well, the costs haven't changed substantially, as I understand it——

Yes, sir?

Mr. Calio. Mr. Chairman, I don't think we can get there from here in the timeframe using the notion of the Omnistar because the shuttle accident did put us in a situation where we would not have a shuttle launch available until sometime after 1992. We do know that the Defense Department has at least stepped down from pursuing the Western Test Range until at least 1992, so we would not have any launch capability available until then to be able to service such a spacecraft.

We really have a difficult technical decision to face because even if we moved off to a Titan IV, that alone would only get——

Mr. Clarence Brown. For Omnistar.

Mr. Calio. For Omnistar, that would only get the satellite into orbit and operating for several years, which is important, but the notion of serviceability could not take place until we were assured that we had a shuttle capability working out of Western Test Range that could rendezvous with that spacecraft. That has not been defined at this point.

Mr. CLARENCE BROWN. We are back to the Landsat, 4-5 type of Landsat, modified as they may be technologically to 6 and 7, but that isn't Omnistar. That is where the contract sits now.

Mr. SCHEUER. I feel like someone trying to punch their way out of a bag of wet kleenex. It seems to me that basically nothing very much has changed. We have refined some of our concepts as to the technology that we ought to use and I don't understand what's holding up this major program that is so clearly in our national economic interests and other interests, too.

My distinguished co-chairman, Ralph Hall.

Mr. HALL. We have more testimony today and we have another full day. I'm still in the fog that they talked about. I guess, Mr. Secretary, you are a great teller of stories and a fine speaker. I've heard you on many occasions. I'm going to give you a story that gives you a way out before I ask you the question.

Mr. CLARENCE BROWN. I think you are overly generous, Congressman.

Mr. HALL. In 1960, several of us went West with LBJ trying to nominate him but a man named Kennedy got the nomination and they asked Mr. Rayburn who was our spokesman, why Kennedy shouldn't be President and he said, the boy's too young. 90 days later he was supporting the ticket and making a speech in New England and one of the reporters asked him about that statement and he said, well, don't be silly, he's 90 days older. [Laughter.]

Mr. CLARENCE BROWN. Somewhere, there was a change.

Mr. HALL. In your letter of March the 4th, you can make the same statement but I'm trying to get your exact position here to where when we look back and at other testimony submitted on Thursday, where you say you believe there are only 2 options, prepare a new 2 satellite plan for congressional consideration or terminate the program. Back on the first page, you also say the Senate Appropriations Committee disapproved the plan stating that it would not result in commercialization without an administrative commitment to a second satellite and additional subsidies.

Mr. CLARENCE BROWN. Thereby removing one option and that was the 1 satellite choice that had been submitted with the budget.

Mr. HALL. But I understood you to say that you took that position because of the Senate's conclusion about commercial viability.

Mr. CLARENCE BROWN. That's correct.

Mr. HALL. Your very next sentence says the Department concurs with the Senate conclusion concerning commercial viability.

Mr. CLARENCE BROWN. That on 1 satellite, you'd have to continue the process or terminate after the 1 satellite.

Mr. HALL. You actually didn't say yes and you didn't say no. I don't understand what you call a place filler, one of them being a place filler. Could you enlarge on that just a little?

Mr. CLARENCE BROWN. Well, let me if I can go back to Mr. McCurdy's exchange and that is whether or not the Landsat 6 and 7 based on the conventional Landsat 4 and 5 but upgraded some in their technology, would in effect be the method by which the greatest potential for it being commercially viable could be achieved. In other words, is Landsat 6 and 7 as good as the Omnistar choice, if we had that choice. That's the question that I am raising for you all and having said it, I have to say that Omnistar is not now a choice because of the shuttle situation.

So, what we may get to is the question that Mr. McCurdy originally asked, if you go ahead and invest in 6 and 7, are you going to be competitive with what our friends and competitors are doing. We are not going to be as competitive I think on that basis as if we had Omnistar. I don't know how to state it otherwise.

Mr. HALL. If you were to re-write or re-dictate your letter of March 4th, would you take a little bit different position on the statement, "or terminate the Landsat commercialization programs?"

Mr. CLARENCE BROWN. I would add at this time or now, because that ultimately is going to change, the statement, I think, was correct when made and it's correct now. I think you have two choices, given the Senate's limitation and the limitation that the House has taken and their judgment is fair. That's what that follow-on sentence means. It is an option and it does not conform to the Landsat legislation and it doesn't quite meet the contract requirements. It is an option. When the Senate points out that they think it doesn't conform to the law and we are not conforming to law and we are obliged to conform to the law, then I have to tip my hat and say okay. That's out as an option, the 1 satellite choice.

Mr. HALL. Thank you.

Mr. CLARENCE BROWN. I want to give you a story in return. When I was a young newspaper man at the end of the war——

Mr. HALL. You aren't going to give me that cat story? [Laughter.]

Mr. CLARENCE BROWN. No. The cat story doesn't translate on the record very well.

In a small town in Ohio, our city status comes at the 5,000 population level, so this was in the early 1950's and the village was changing to a city and it hired a young Marine officer returned from the war who is in a hell of a lot better shape than I was at the time, to be the administrator to change all the regulations in the community to conform to the city's status.

He had done that job, done it very well and had been paid for the year that it took him to do it about $15,000, which then was an exorbitant amount of money to pay to anybody but it was logical for a demanding job.

When he left the job, they decided to take a retired school superintendent who had his teacher retirement and pay him $5,000 to finish up the job, dot some i's and cross some t's and so forth. I wrote the story about 2 o'clock one morning after the City Council meeting and said that they agreed to pay Mr. Gurke $5,000 because the job was not worth $15,000. About 4 o'clock in the afternoon, the Marine came by and was ready to punch me in the nose. I said, I don't know what you are mad at. He said, because you said the job for which I got paid $15,000 wasn't worth that money, it was only worth $5,000. I said, no, I didn't say that, I meant it was only now worth $5,000, when you did it, it was worth $15,000 clearly, and he said, you didn't say now, you said it was not worth $15,000. I said, you aren't going to punch me in the nose for three letters, are you.

I trust that for saying that currently our problem is that we have only 2 choices, that's exactly where we are. We have only 2 choices. We have a choice either to terminate the contract and have no satellite up or we have a choice to go to 2 satellites and that choice has been submitted to OMB for their tender mercies.

Mr. HALL. I thank you, Mr. Secretary.

Mr. SCHEUER. Congressman Tom McMillen.

Mr. MCMILLEN. Thank you, Mr. Chairman.

I particularly have a keen interest in this program because EOSAT is located in an adjoining congressional district of mine and really what I wanted to ask today was to get an idea as to maybe the differences in objectives between the way we view this program and the way the Japanese and French view it.

The Japanese and possibly other nations do not seem to view commercialization or creation of a profit making industry as a goal of remote sensing. The Japanese appear to intend to use remote sensing as a tool in assessing and developing global resources.

Would you agree with that assessment of Japanese entry into this area?

Mr. CLARENCE BROWN. I think it's the same reason we are in the business.

Mr. MCMILLEN. Carrying that forward, if our industry in 10 years was not showing a profit, having a positive bottom line, do you think we should abandon that, abandon remote sensing and be totally dependent upon the Japanese and the French?

Mr. CLARENCE BROWN. Well, profit is a relative term, I think, any time the Federal Government is putting up $250 million as part of the cost of the operation. If somebody gave me $250 million, I could probably make a profit somewhere in my operation. The question is a matter not of profit but of priorities for the Federal Government. We don't set in the Commerce Department those priorities for the entire Federal Government. That's done elsewhere.

Mr. MCMILLEN. Are there other benefits of the technology that militate towards the United States maintaining its capability?

Mr. CLARENCE BROWN. There was some discussion of that earlier, Mr. McMillen, as to whether or not one of the darker parts of the operation of the Federal Government or less public parts of the operation of the Federal Government benefit from this and that's an area in which I am not competent to speak.

Mr. MCMILLEN. I guess the question that I have really is when you view all this, are you concerned that the abandonment of Landsat will lead to a decrease in United States competitiveness, not only in this area but in artificial intelligence and computer processing and the like?

The thrust of my question is in my previous life, I've done some venture capital involved in those areas and to me this is almost analogous to a venture capital investment; certainly the public sector is involved here. We are making an investment in clearly a high risk area but also a high reward area.

If we abandon this and we throw it on to the private sector to somehow fend for themselves, what inevitably happens is because of the uncertainty of the marketplace, the inability to get financing, all the entrepreneurial kind of energies here are really dissipated and that concerns me because I think the other consequence of this is we will be totally dependent on the Japanese and French who have other motives.

Mr. **Clarence Brown**. Mr. McMillen, for us, for the Japanese and the French, it is not a private sector enterprise alone. It is one in which, as I said, the Federal Government puts up now $250 million. In their case, they put up the money, too. If I can strain the analogy a little bit further, as members of Congress, you all on this Committee are part of the Board of Directors of the group that spends the $250 million and that decision has to be made to some degree by the Board of Directors and by its Chief Executive Officer who sits in the White House.

We are branch managers, if you will, of the operation. If the Board of Directors wants to invest $250 million in this project or $360 million or $450 million, or you pick a number, we will carry out the instructions of the Board of Directors and the Executive Branch.

Mr. **McMillen**. Are you concerned then that if we do abandon this, that we will have a consequential loss in competitiveness in not only this area but other areas as well?

Mr. **Clarence Brown**. We certainly will have a loss of information and the Department of Commerce has supported in the past, the gathering of that information.

Mr. **McMillen**. Do you view information as being analogous to our competitive position in this country in areas like artificial intelligence and so on?

Mr. **Clarence Brown**. Well, again, you are getting into an area that I can't speak to with any authority.

Mr. **McMillen**. Really, what I wanted was to hear your thoughts on I guess the differing objectives between the Japanese and the French and our South. We want to push the baby to walk on its own as quickly as possible. I think the Japanese and the French are willing to walk with that baby until it clearly can walk a little further on its own.

Mr. **Clarence Brown**. Well, I don't think there is an expression here that we are unwilling to walk with the baby. The question is how much, you know, to what extent do we put the support into it and that's a judgment that we don't make individually in the Department of Commerce. If we set our own budget, it would be a different matter. We don't.

Mr. **McMillen**. Just a question of information. If you had the total, the commitment the Japanese and French have made in this area as compared to our public sector commitment, comparing the two public sectors, what would be the comparison or differences?

Mr. **Clarence Brown**. I'll have to ask Mr. Calio for that. He's much more gifted on the comparisons of what's being done in that field than I am.

Mr. **McMillen**. To date, we spent $1.5 billion. What have the Japanese done in that area in total? Any estimates? Or the French?

Mr. **Clarence Brown**. Getting a lot of negative head shaking here.

Mr. **Calio**. The French, I guess, on the satellite component part of it, it has been half a billion dollars so far, I think. I don't know how much technological development they have put into it and what the costs were.

The Japanese are just stepping up to it now.

Mr. **Clarence Brown**. If you ask that question of us with reference to airplanes, an item in trade, we could probably give you an answer because that's mostly public information and we could tell you what the Air Bus has spent in development versus what we have spent, because we have to know that for questions of subsidies and dumping and all that.

In this field, the figures are not as available as they are for those commercial fields.

Mr. **McMillen**. In conclusion, Mr. Chairman, it seems that the analogy to venture capital funds again, it seems to me, you know, in venture capital investing, you can put a lot of money into something and your timing may be wrong and then someone comes along just after you leave that marketplace and that investment can flourish almost overnight. Clearly my concern is that we may be doing that in fact. We may be relegating all this to the Japanese and the French and letting them really ride this profit curve or even this curve towards the future.

Mr. **Clarence Brown**. Well, I think that's a fair analogy, Mr. McMillen. What we can contribute is our part of that contribution, what you will get from the private sector and other testimony, what you get from other folks is going to be part of the judgment that you and the Administration and the Office of Management and Budget in fact have to make with reference to this issue.

Mr. **McMillen**. Thank you, Mr. Chairman.

Mr. **Scheuer**. Congressman Dave McCurdy.

Mr. **McCurdy**. Mr. Chairman, I just have one last question. I see Secretary Latham walk in and it relates to him and he'll have a chance to amplify his position in a minute. I wanted to get Commerce on the record.

In a recent interview, DOD representatives indicated there was no need for NOAA's civil polar orbiting weather satellites when DOD has 2 that provides similar data. Would you comment on what your position is on the polar orbiting weather satellites and whether or not this would be a potential source for funding?

Mr. **Calio**. With due respect to Secretary Latham's comment, we have a satellite right now called NOAA 9 whose sounder isn't quite working properly, and we have a cross draft data system with the Air Force right now that is in place so that if an Air Force satellite could take the data that we needed, it could be transmitted to us very quickly and put into our computation for developing a forecast to replace that sounder.

That is not taking place. The Air Force DMSPs do not collect exactly the same kind of data that we need on the same frequency we need it to initialize our models for producing the forecast.

Mr. **McCurdy**. Why not?

Mr. **Calio**. They have two entirely separate functions.

Mr. **McCurdy**. Why is it that, well, this could be the subject of another hearing, but at some point we need to address the question of whether or not there is duplication and why the Air Force has to have its own separate system and everyone else has theirs, but I appreciate——

Mr. CLARENCE BROWN. I think that is a question, Mr. McCurdy, that you should ask the Air Force, why they have to have a separate system. We have no desire to militarize the Weather Service.

Mr. MCCURDY. You like yours and you want them to change, or what?

Mr. CLARENCE BROWN. Well, there is an international tradition for the Weather Service in this country to share data. Even in the darkest hours of war, data was shared in the Weather Service in the United States and abroad.

Mr. MCCURDY. Why can't they be a common system someday?

Mr. CLARENCE BROWN. As far as we are concerned, we would be happy to share all of our data with the military, which we do. Whether their system requires them to get different kinds of information from their satellites also producing weather information or whether they feel there is a necessity for some redundancy because of the significance of the military role is something, again, that you would have to pursue with them; but we feel fairly strongly about not having the Weather Service in the United States operated by the military so that we don't have to at some point run up against the question of whether or not we can get the data because it is now a military secret. Unfortunately, we have international agreements that require us to make that information available, and those have been observed historically in the worst of times.

Mr. CALIO. And the Air Force has taken that position in the past as well, that we maintain that communication capability in the free world through the WMO and have tremendous data exchange that takes place.

Mr. MCCURDY. Thank you.

Mr. SCHEUER. Bud, would your Department favor a joint venture on this whole Landsat enterprise with the Japanese or the French or both if there is any interest on their part.

Mr. CLARENCE BROWN. Mr. Chairman, I don't know that we have addressed that in the Department, and I am not sure that I can speak to it. That is a question that better be asked the Secretary. He might be willing to respond to you either in some written way. I am not competent to give the Department's position on that issue, and it is a very difficult question to ask in the climate in which we find ourselves over the last few days.

Mr. SCHEUER. We appreciate your testimony, both Dr. Calio and you, Bud. We rely on your dedication to the goal of having a viable American Landsat program, as we do with your predecessor at the witness stand from the OMB, and it is our confidence in you and Dr. Calio and our OMB colleague that give us the confidence to feel that out of this seemingly impenetrable fog, that something good will emerge, hopefully in the next couple of weeks, and that we will be able to negotiate—when I say "we," I mean the appropriate committees of the House and the Senate—we will be able to negotiate with you and with the OMB a viable Landsat enterprise.

Mr. CLARENCE BROWN. Thank you, Mr. Chairman. Let me just say that as the chief budget officer for the Department, I first negotiate with Dr. Calio on what NOAA wants, then I have to negotiate with OMB on what I can get for NOAA, and then the Congress does its magic on the budget after that. So the process, whether it works or not, is still viable, and we think that out of these hearings and the testimony that you will get further from others, you will be able to get to some judgment to give us some advice on this problem.

Mr. SCHEUER. I would ask unanimous consent that the members be able to submit questions in writing and that we hold the record open for 10 or 12 days. There being no objection, so ordered.

We thank you very, very much for your testimony.

We will now declare a recess for about 12 minutes while we catch this roll call vote.

[Recess.]

Mr. HALL. I think in the interest of time, we will get underway, and I think there has been an agreement that because Mr. Secretary Latham has another engagement, that we will take him out of order, and I guess I can ask for unanimous consent to do that. If there is objection? The Chair hears none.

Mr. Secretary, if you will proceed.

I would like the record to reflect there is a full panel of empty chairs.

Mr. Secretary, it has been our practice to ask you to give us a seven or eight-minute summary of your testimony, if such is agreeable to you, and if it's an easy way for you to do it. If not, we are very grateful to you for your appearance here and taking up your very valuable time.

STATEMENT OF HON. DONALD C. LATHAM, ASSISTANT SECRETARY FOR COMMAND, CONTROL, COMMUNICATIONS, AND INTELLIGENCE, DEPARTMENT OF DEFENSE

Mr. LATHAM. Thank you very much, Mr. Chairman. I appreciate putting me in this order. I do have another hearing this afternoon, but I was very anxious to come over and talk to you today about Landsat.

I have actually two statements for the record, one that is unclassified, and the second a classified statement for the record that we will submit through the proper channels to the committee that goes into considerably more detail as to the Department's current and projected uses of Landsat data as we use it in the department today.

Mr. HALL. So the ones that you note will go into the record, and if you indicate otherwise, they will not.

Mr. LATHAM. All right, sir. Fine.

As I noted in the unclassified statement for the record, sir, the Department has for several times, and would continue to use and make valuable use of Landsat imagery for a variety of purposes.

For example, the Corps of Engineers uses the current Landsat imagery for watershed management. We also take Landsat imagery, which as you know can take imagery over an area about 100 by 100 square miles and allows us to look at very large areas of the earth for crop management, for change detection, for example, with the current imagery capability of the U.S. Landsat. One can see very major construction projects, and we can then view the earth from one year to the next and notice changed detection in major various programs on the earth.

We can actually do some of this automatically today where we can actually highlight change detection with automatic computer aids.

We can also use Landsat today to probe down through the ocean depths because of the various bands, imaging bands that are on the U.S. Landsat. We can actually see down through clear water to depths as much as 40 meters, and this has been very useful in hydrographic mapping and the Defense Mapping Agency has made use of that in allowing us to find underwater obstacles and other features under the water that will help in making better charts and maps throughout the world.

In fact, we find that using Landsat imagery in conjunction with other techniques allows us to generate scenes and do things that we could not do otherwise.

For example, we can generate with computer-aided techniques what we call perspective scenes. That is a three-dimensional imaging scene from computer-aided enhancements. So we found it quite useful.

In contrast to the current and projected foreign systems which do not cover the same bands, even though one of them currently has somewhat higher resolution, they lack the band coverage that ours has, and we believe that that is quite important.

For example, the current Landsat was useful in watching events unfold in the Chernobyl reactor situation in the Soviet Union.

So in general we find the Landsat imagery of significant use to the department. It has been our position that the program should continue, and that since it was a program that was sent out to be competed in the commercial sector and was to be commercialized under the auspices of the Commerce Department that it should continue that way and it should be funded.

I will just summarize it there. Thank you.

[The prepared statement of Mr. Latham follows:]

STATEMENT FOR THE RECORD

BY

MR. DONALD C. LATHAM

ASSISTANT SECRETARY OF DEFENSE
COMMAND, CONTROL, COMMUNICATIONS, AND
INTELLIGENCE

BEFORE THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

31 MARCH 1987

MR. CHAIRMAN, MEMBERS OF THE COMMITTEE:

THANK YOU FOR THE OPPORTUNITY TO TESTIFY IN SUPPORT OF THE LANDSAT PROGRAM.

THE LANDSAT SYSTEM IS A NATIONAL ASSET THAT CUTS ACROSS COMMERCIAL, CIVIL AND MILITARY SEGMENTS OF OUR SOCIETY. ITS APPLICATIONS ARE MANIFOLD, AND IT HAS SPAWNED NEW AND POWERFUL ANALYTIC TECHNIQUES AND SUPPORTING TECHNOLOGIES FOR THE BENEFIT OF AGRICULTURE, TRANSPORTATION, LAND MANAGEMENT, MAPPING, COASTAL AND SHALLOW WATER CHARTING, ATMOSPHERIC AND OCEANOGRAPHIC STUDIES, AND MANY OTHERS.

AMONG THE ANALYTIC TECHNIQUES THAT HAVE EMERGED TO EXPLOIT LANDSAT IMAGERY IS THE ABILITY TO PARTITION THE EARTH'S SURFACE INTO REGIONS THAT ARE HOMOGENEOUS WITH RESPECT TO VEGETATION, SOIL TYPE, SLOPE, AND OTHER LAND COVER AND EARTH SURFACE CONDITIONS, AND TO CLASSIFY THESE REGIONS INTO SPECIFIC CATEGORIES. ALTHOUGH THESE TECHNIQUES ARE NOT YET FULLY AUTOMATED, AND THEY STILL REQUIRE CONSIDERABLE EXPERT HUMAN GUIDANCE TO ACHIEVE HIGHLY RELIABLE RESULTS, THE TREND OVER THE PAST FEW YEARS DEMONSTRATES THAT THESE TECHNIQUES ARE BECOMING MORE ROBUST, AND PROJECT A HIGH DEGREE OF AUTOMATION FOR THE FUTURE. THESE TRENDS PROMISE A HIGH PAYOFF IN EFFICIENCY AND ACCURACY OF PERFORMANCE FOR MANY DEFENSE FUNCTIONS.

THE U.S. ARMY CORPS OF ENGINEERS HAS UTILIZED LANDSAT DATA EXTENSIVELY FOR WATERSHED MANAGEMENT WITHIN THE UNITED STATES.

LANDSAT UNIQUELY PROVIDES A SIMULTANEOUS OVERVIEW OF A VERY LARGE AREA -- ROUGHLY A SQUARE 100 MILES ON A SIDE.

LANDSAT PROVIDES A VALUABLE UNCLASSIFIED BRIEFING FORMAT FOR U.S. AND FOREIGN NATIONALS.

LANDSAT IMAGERY IS SUITABLE FOR THE PRODUCTION OF PHOTO-MAPS IN CRISIS SITUATIONS IN REMOTE AREAS.

NEW AND MORE POWERFUL ALGORITHMS FOR AUTOMATED REGISTRATION, CHANGE DETECTION, SCREENING OF WEATHER AND OTHER TEMPORAL CHANGES, AND FEATURE CLASSIFICATION, AND LANDSAT-BASED GEOGRAPHIC INFORMATION SYSTEMS WILL EMERGE TO MULTIPLY THE UTILITY AND ECONOMY OF LANDSAT EXPLOITATION.

IF LANDSAT-6 AND -7 ARE ALLOWED TO ACHIEVE THEIR PLANNED INCREASES IN RESOLUTION TO 15 METERS, ADDITIONAL EXPLOITATION WILL UNDOUBTEDLY ARISE.

CURRENT AND PROJECTED FOREIGN SOURCES LACK THE SHORT WAVE INFRARED AND THERMAL IMAGING CHANNELS WHICH ARE KEY DISCRIMINANTS FOR MANY TECHNICAL APPLICATIONS AND EVALUATIONS. THEY ALSO YIELD IMAGES WHICH PROVIDE AT MOST ONE NINTH THE AREA COVERED BY A SINGLE LANDSAT SCENE.

IT IS IRONIC THAT THE FUTURE OF LANDSAT IS IN DOUBT PRECISELY AT A TIME WHEN IT PROMISES HIGHLY SIGNIFICANT AND UNIQUE BENEFITS TO DEFENSE MISSIONS. ALTHOUGH THE SYSTEM IS NOT OPTIMIZED TO SATISFY MOST OF OUR SPECIFIC REQUIREMENTS, WE FIND LANDSAT IMAGE DATA UNIQUELY SUITED TO THE ENHANCEMENT OF MANY IMPORTANT PRODUCTS. THE LANDSAT SYSTEM WILL SURELY INCREASE IN ITS CONTRIBUTION TO OUR NATIONAL SECURITY -- BUT ONLY IF IT SURVIVES THE SERIES OF DIFFICULTIES CAUSED BY THE PROCESS OF COMMERCIALIZATION ITSELF.

THE ACT OF ABANDONING LANDSAT IN THE FACE OF FRENCH AND JAPANESE COMPETITION CONSTITUTES A BAD SIGNAL TO AMERICAN INDUSTRY AND TO OUR ALLIES DURING THIS PERIOD OF AMERICAN HISTORY AND IS AN ADDITIONAL CONCERN. NOW IS THE TIME FOR A RENEWED COMMITMENT TO LEADERSHIP IN SPACE TECHNOLOGY, ALLIED EXPLOITATION OF SPACE, AND SUCCESSFUL COMMERCIALIZATION OF SPACE TECHNOLOGY.

WE STRONGLY BELIEVE THAT LANDSAT SYSTEM DESERVES THE FULL SUPPORT OF THE UNITED STATES GOVERNMENT TO ASSURE FOR THE LAUNCH AND OPERATION OF LANDSAT-6.

Mr. **HALL**. Thank you, Mr. Secretary. I will just ask you some general questions and try to run the clock until the Chairman gets back and some other members who I am sure have some questions for you, and I am sure we can glean from your full statement and from the additional statement you are going to submit to us.

But as evidenced by photographs—and I was just looking at a photograph here in 1987, Soviet military power. I know you are familiar with that.

Mr. **LATHAM**. Yes, sir.

Mr. **HALL**. DOD uses Landsat and other data. What would be the likelihood that we would—on page 68 there is a picture, the Soviets have modernized their military capabilities on the Japanese Northern Territories Islands with the deployment of certain specifics there.

What would be the likelihood that we would continue to get that type information if we didn't pursue the full development of Landsat?

Mr. **LATHAM**. I think it would be diminishingly small. The coverage of Landsat is significantly greater than, for example, the French SPOT system. A SPOT image is about one-ninth the square area that the Landsat is.

As I mentioned, the imaging bands are different, and the newer Landsat, No. 6 and 7, if they go forward, would have resolution that approaches what the current French system does, and that would aid us even further in producing imagery such as that that could be released at an unclassified level to further educate the American people as to what is going on in the world, and to allow us to do other exploitation things with the imagery.

So it could be even more valuable.

Mr. **HALL**. There's a corollary there between the precious metals we now get from South Africa that we can also get from the Soviet Union; if we cease to be able to get them from South Africa, they are not going to be quite as available to us when we really need them.

Mr. **LATHAM**. Well, that's right, sir. For example, we are able, because it is a U.S. owned and controlled asset, to task the system, and we have worked out an arrangement to do that with EOSAT. We can task the system to generate certain imagery at certain parts of the world in confidence, whereas that would be extremely difficult, if not impossible, with foreign sources, so that the availability of data is much more prompt.

Mr. **HALL**. How would you address that? How would you assure yourself of getting some data from foreign systems?

Mr. **LATHAM**. I don't think there is any way to assure us of that. We can negotiate a contract with some of these foreign sources through the Defense Mapping Agency, which is the focal point in the government for procuring such imagery, and hopefully, if you ask, you might get it. But you just may not, or you may not get it very timely. So that that is going to be potentially a very serious problem.

For example, in one particular area of the world, we needed some topographic data, and some soil condition data for some planning purposes, for potential contingency operation, and we were able to get Landsat imagery that would allow us to make those judgments very, very rapidly, and that was a type of thing we need to have under our control.

Mr. **Hall**. We have had some other Assistant Secretaries and department heads give us some timeframes, and you know say that they could tell us in two weeks or that's something they can't discuss, and maybe you can't answer this question, but has the Landsat funding crisis been discussed at the Cabinet level or with the senior Interagency Space Corporation group, or with the National Security Council? Or can you tell us? Has that been an item of discussion——

Mr. **Latham**. Yes, it has, sir.

Mr. **Hall** [continuing]. That you all have bantered around and kicked around?

Mr. **Latham**. Yes, sir, it has been brought to the attention of the Secretary of Defense by myself on more than one occasion. Secondly, he has brought it to the attention of Mr. Carlucci, the National Security Advisor, and Mr. Gates, the acting DCI, Director of Central Intelligence, has also written to Mr. Carlucci very recently expressing his concern about the Landsat programs, and asked for, as has Mr. Weinberger, a Cabinet level meeting to determine the future of the program. So it has been brought to the very highest attention so far, and I would hope that it could be brought to the President's attention because it was his original intention to have this program continue as a commercial venture, and I think he should have the opportunity to hear it out again.

Mr. **Hall**. In the March 4th letter from Commerce to OMB, we kicked around here and discussed, Commerce estimated the cost of two Titan II launches provided by DOD at about 70 million. Do you think that's a reasonable estimate?

Mr. **Latham**. Yes, sir, that's a——

Mr. **Hall**. And what are the variances in there? What can change that?

Mr. **Latham**. The estimates are from 35 to 42 million dollars, is the current estimate per launch. So the $70 million number in FY 1986 dollars is a good number right now. We intend to provide a more precise number in April. The only thing that could change it—well, there are several things, I guess, could change it, but these are refurbished Titan IIs, and we are building Titan II launch pads and so on.

I don't expect much upward growth in that number, and the availability of the boosters has been assured in 1990, '91, so there could be some upward cost growth, but I don't think it would be much more than what I've cited, and we will get a more firm number in about two weeks.

Mr. **Hall**. Mr. Secretary, I do thank you.

Mr. **Latham**. Yes, sir.

Mr. **Hall**. And I yield now to the Chairman, with my assurance to the Chairman that I have already asked the most important questions. [Laughter.]

Mr. **Latham**. Mr. Chairman, for your information, the Secretary is submitting a record—statement for the record and an additional statement that would be for your files only, and I think that will be very helpful to us. A more detailed classified statement for the record that describes in more detail some of the specific and projected uses of Landsat by the Department.

Mr. **Scheuer** [presiding]. All right.

Mr. **Latham**. At your convenience also I would be glad to come back at whatever time you'd like, and I have a classified briefing that has some very interesting things in it, I believe, that you would like to see—I could come to your office, sir.

Mr. **Scheuer**. We'd like to do that very much, and we will plan that in the next—this week or next week.

Mr. **Latham**. All right.

Mr. **Scheuer**. Let me ask you, if the Landsat system dies, what is the likelihood that the DOD or the intelligence community will fund and fly its own multispectral satellite system to fill that void?

Mr. **Latham**. I don't think the probability is very high at all. We would just not be able to afford to do that, because the delta costs, let me call it, to keep this program going on the scale of things in this country seems very affordable to us, and that it should continue. And as I mentioned while you were out of the room, both Mr Weinberger and Mr. Gates have told Mr. Carlucci that, and that we believe that it is a Commerce responsibility to fund that program.

Mr. **Scheuer**. It's Commerce's responsibility?

Mr. **Latham**. Yes, sir.

Mr. **Scheuer**. But still—I don't know if you were here this morning——

Mr. **Latham**. No, sir.

Mr. **Scheuer**. They feel very strongly that it's a user directed program, and if the users aren't willing to express some interest in it and assure some forward funding, they feel, well, there's no purpose to it all. And they feel the Defense Department has the capability of doing it very easily. It's an infinitesimal sum, a couple of hundred million dollars we're talking about, and they feel that it's user-driver and user-directed, and if the users don't want it, what's all the hullabaloo?

Mr. **Latham**. Well, that's a rather strange position to take, when the President has personally said that he wanted to have the commercialization of this multi-spectral imagery capability, and so directed it. There was a competition held, and a corporation was selected and put into business to do it. At the time the government, the federal government indicated a willingness at that time to support a certain level of funding in order to get the corporation and the thing commercialized, and that was to be done by the Commerce Department, and they should not back down on that responsibility.

The Department of Defense and the intelligence agencies are in fact the biggest customers in a cents. We buy a very large amount of the current imagery and we project to buy a considerable amount in the future. Some estimates range as high as $10 million a year worth of imagery from the Landsat.

Mr. **Scheuer**. How much are you currently buying?

Mr. **Latham**. It's a few million a year; something on the order of a few million up to perhaps five today.

Mr. **Scheuer**. They don't consider that a very significant level of funding or purchasing of their product.

Mr. LATHAM. Well, they——

Mr. SCHEUER. And they would like to see a more significant evidence of your interest over the long haul.

Mr. LATHAM. Well, I'm not sure what we can do, short of bailing them out of the situation they're in. And as I have indicated in other media, I believe that this country needs to prioritize its requirements in the face of budget realities. And I have suggested that the Commerce Department should go back and reprioritize internally to fund this program fully, and Defense will do everything we can to support it, short of funding it, and that's the position Mr. Weinberger has taken very clearly, that it is their responsibility to do that, even though we are a customer, as are many other agencies.

Mr. SCHEUER. How much are you currently purchasing of SPOT?

Mr. LATHAM. Very, very little. I don't know the dollar amount, but it's extremely small so far, and as I have indicated, it's not clear that—how well you can depend, if at all, on foreign sources. And, of course, SPOT does not have the same capability that the Landsat currently has today in terms of band coverage.

Mr. SCHEUER. In terms of quality, accessbility, timeliness and so forth, do you consider Landsat superior to SPOT?

Mr. LATHAM. Yes, sir, I do, and especially the newer Landsats would be much more superior.

Mr. SCHEUER. Elaborate on that.

Mr. LATHAM. Well, because you cover with the Landsat the far infrared bands and short wave length IR bands, and while it is today 30 meter resolution imagery and SPOT is allegedly 10, if you looked at what we did with Landsat, for example, on the Chernobyl case, because of the long wave length IR, we could see a number of things that you could not see with SPOT, and it is true in many, many other applications. The band coverage is very significant, we think, in terms of what you can do and cannot do with the product. And so resolution is only one factor in the situation.

Secondly——

Mr. SCHEUER. Excuse me.

Mr. LATHAM. Yes, sir.

Mr. SCHEUER. I take it that your own satellite that provides a two-inch resolution, that is far superior to any of the other satellites in terms of resolution. Still, it doesn't provide you with the intelligence data that you would need on the broad scale that you would get it from Landsat.

Mr. LATHAM. The Landsat system, because of its current optical design and so on, covers about a hundred by a hundred square miles to this much more gross resolution. But you get broad area search capability with the Landsat which you cannot get either with SPOT or certain other systems. And so it has great value in being able to survey very large areas very rapidly, and as a result you can—you can do large feature terrain changes, you can look from one year to the next.

For example, we can tell whether there's an air field being constructed in some part of the world or not, or highways have been changed, or new missile launch silos, even, put in because of the features that you can actually discern from these images if you are very careful in how you use them.

So it has a number of features and value that you would not be able to get, perhaps, from other systems and it is under U.S. control.

Mr. SCHEUER. So what you are saying—what you are telling us, as I get it, is that no other system for which we have assured continuity of availability within our control offers the broad scale intelligence information reach that Landsat does?

Mr. LATHAM. That's correct.

Mr. SCHEUER. And you would say then that it's in our national security interest to continue the continuity of the Landsat flow of——

Mr. LATHAM. Yes, sir, I would.

Mr. SCHEUER [continuing]. Highly valuable intelligence information?

Mr. LATHAM. Well, let me cast it much more broadly than intelligence. The Department makes use of this information for a wide variety of purposes, only some of which one would classically call intelligence. I guess if you find an air field one year to the next, that's intelligence, but there are many, many other things that we use it for that are beyond the intelligence apparatus.

Mr. SCHEUER. When you say we, you mean the Department of Defense?

Mr. LATHAM. Department of Defense, yes, sir. And, of course, other agencies in the federal government make great use of it such as Agriculture uses it for——

Mr. SCHEUER. Oh, yes. We've already covered that. We will have another panel after yours.

Mr. LATHAM. Yes, sir.

Mr. SCHEUER. How would you feel about the appropriateness and the benefit to our country of a joint venture between our country and either or both of the French and the Japanese to continue to operate at least a two-satellite system up there, information from which we would share?

Mr. LATHAM. I wouldn't think too much of that. I'd rather go it alone, personally. I just think that this nation has got to put itself into a position where it says that we are going to continue our leadership in space, and I think that's very important. There are a number of Third World nations that depend today on Landsat imagery for a variety of purposes. They look to the United States for that imagery and for that support and for analysis that can be gleaned from it, and I think that there are a number of intangibles as to the value of this capability that go beyond dollars and cents in terms of political good will, and international relations. And I think it needs to be cast in that light, and I think we should keep it going, and not abrogate our position in this area to the Japanese, the French or anybody else.

Mr. SCHEUER. How do we transfer you to a command position in OMB? [Laughter.]

Mr. HALL. Mr. Chairman?

Mr. SCHEUER. Mr. Congressman.

Mr. HALL. Is part of your reluctance to go it with say Japan based on military fears, or history of past aggression?

Mr. LATHAM. No, sir, not at all. I think they have their program and we——

Mr. **Hall**. As a matter of fact, they are well ahead of us, aren't they, at this time? And aren't they going it alone? And would it not be somewhat financially practical—and I don't think they'd do it—but to tie into them with some type of international scientific cooperation to avail ourselves of the technology they have already developed and the expenditures they have already made?

Mr. **Latham**. Well, I think that that would be useful to do, and I believe that the Japanese will perhaps make available the information from their newest particular satellite. In fact, there is a picture from that satellite in one of the recent magazines. There are other very strong economic reasons that I believe some of these nations will not want to share full data rights from these satellites.

For example, by doing the worldwide scans that you can with these multi-spectral satellites, you can actually start doing very useful economic projections on grain, for example, other economic things that are of significant interest to Japan, such as fisheries and fishing options and things of that nature. So there is a broad economic plan, I believe, that the Japanese have for the use of this information that goes beyond any of the applications. We have tended to overlook that. And I don't believe that we should necessarily tie in with them on this. I don't know what we would gain necessarily at all.

Mr. **Hall**. I'm not trying to get you to change your mind. If you narrow it down to the two, Japan and France, you'd lean more heavily toward going it with Japan, wouldn't you?

Mr. **Latham**. I don't know, really, sir. I don't—let me say this. There is nothing that either country has technologically we don't have significantly better technology and capability to put in space if we wanted to. It's a matter of commitment. This nation ought to commit to being the leader in space, and we should not abrogate that responsibility, period.

Mr. **Hall**. If we abandon Landsat, if we fail to pursue it, even as costly as it is, that's just one hell of an indication to American industry and to other people in the world that depend on it, isn't it?

Mr. **Latham**. Yes, sir, I believe so.

Now Commerce can cringe, and you can say "You're from Defense, and you guys are the big spenders," and all that, but frankly on a national scale, this thing should be funded, this program, somehow.

Mr. **Hall**. I certainly agree with you.

Mr. **Scheuer**. And I take it, you feel that we would be living in a fool's paradise if we abandoned the field and simply relied on purchasing this information from the French or the Japanese or both?

Mr. **Latham**. Yes, sir, I agree. There are a number of things that we have learned to do just in the last couple of years and we're still learning that this imagery provides that we never realized we could derive from it before, and not just being able to see city streets and things like that. You can see off SPOT.

There are many, many other very important things that can be gleaned from these data, and we would believe that that's terribly important for this country to have that capability and that it be shared with the civil sector, the civil agencies as well as Defense, and that it's just in the national interest to do that.

And that's what I think the President intended when he said, "Let's commercialize this capability and keep it going."

Mr. **Scheuer**. Well, the President is a patriotic man. I don't have any doubt whatsoever. Nobody in this Congress has any doubt that he is a superbly patriotic man.

Mr. **Latham**. Yes, sir.

Mr. **Scheuer**. Why do you think the Administration has, in effect, walked away from its commitment to be a major player in this space, Landsat sensing?

Mr. **Latham**. Well, I'm not sure they have walked away yet. As I indicated earlier when you were out of the room, sir, the issue has been, I think, joined now at the level of the National Security Council. Both Mr. Weinberger and Mr. Gates, the Acting DCI, have expressed strong interest in this program and have asked to have a Cabinet-level meeting with the President to discuss it. So I don't think it's been walked away from yet.

I think there's some interesting things going on, which are, by some people, to try and have others fund the program, when I believe they should.

Mr. **Scheuer**. Well, do you notice any watering down of the Commerce Department position since Bud Brown's letter of March the 4th, less than 30 days ago, to the current position that he presented to us today?

Mr. **Latham**. I wasn't here this morning when he presented his position, but I'd heard what it was. I guess it hasn't changed very much from what it was before, and my feeling is, again, back that if, in fact, OMB believes there are not additional funds to be allocated to the Commerce Department, then it would seem only reasonable, on the basis of priorities, to reprioritize and fund Landsat to the exclusion of something else, which we have to do in the Defense Department all the time to make priorities and make judgments, and some things just don't go forward.

And I have suggested that one of the areas is, in fact, the meteorological satellite programs, that we have other meteorologic satellites, that we do not have another Landsat in the Defense Department or anyplace else, and so do you want to give up completely a capability in that manner.

Mr. **Scheuer**. The Defense Department budget is on the order of magnitude of more or less $300 billion.

Mr. **Latham**. Yes, sir.

Mr. **Scheuer**. Well, what we're talking about here is a fraction of 1 percent of that budget. I mean, like a tenth of 1 percent or at the most a fifth of 1 percent.

If you believe, as we believe, that it's really highly in the interest of the United States, not only from the security point of view but the economic and many other points of view, from our position in the world, our respect and credibility around the world, if you believe that it's important for us to be a major player in space, and OMB and the Commerce Department are obviously thumping around trying to get the Defense Department to come in and play a role—we mentioned this morning, sort of tongue in cheek, that a couple of toilet seats and a hammer or two would almost make up this amount that we need—but seriously speaking, when we're really talking about one-fifth or one-tenth of 1 percent of your budget, why don't you bite the bullet and come in and help them fund it?

Mr. LATHAM. Well, I've asked the Secretary that question, and he, as I said, is very supportive of the program and believes it is an important program, as does Mr. Gates, but that it was a Commerce responsibility in the Government to fund it, and they should step up to it. And that was his final position.

I approached him on that with this argument in mind, but he felt quite strongly that is was the responsibility of another agency to do this, and they should step up to do it.

Mr. SCHEUER. Now I take it you're referring to discussions that took place late last year within DOD.

Mr. LATHAM. Yes, sir.

Mr. SCHEUER. What possible level of contribution that they might make.

Mr. LATHAM. Yes, sir. We've discussed it on more than one occasion, in fact as recently as just this past week. In fact, this morning I got a note back from Mr. Taft about it, the Deputy Secretary, so it is an ongoing and current dialogue as to who should pay for this important capability, and right now it is our position that Commerce should step up and do it, as was originally intended, despite the fact that DOD's budget is what you say it is.

Mr. SCHEUER. Well, we'd like to see the Commerce Department belly up to the bar, too. But they're beset with doubts. They're in this Hamlet-like state of irresolution between Commerce and OMB, and we can't seem to get them to get their act together and galvanize our national will to move ahead.

Now you people apparently had serious discussions late last year about coming in and making a major contribution to OMB and Commerce, but still at an infinitesimal fraction of 1 percent of your budget.

You know, we'd like this thing to be resolved.

Mr. LATHAM. Yes, sir.

Mr. SCHEUER. What was the order of magnitude of the funding that you informally discussed toward the end of the year?

Mr. LATHAM. What we informally discussed with Commerce was basically the launch cost, to have DOD fund—pick up essentially the launch cost, plus some other costs, a total of maybe something under $100 million to keep the program viable. It was on the order of magnitude of that, spread over three fiscal years, roughly $10 or $15 million in 1987 and about $30 million or so in 1988 and 1989. Those are the rough numbers we discussed at one time, and we had a difficult time, in fact, finding out from Commerce exactly how much was needed, because they do have a funding line, and how much they really wanted to put into Landsat was very difficult to find out over months and months, frankly. But it came out roughly those numbers that we were discussing.

Mr. SCHEUER. Is it your feeling that that order of magnitude of involvement by DOD would more or less satisfy OMB's feeling that, by God, that user community ought to show more confidence and more concern in this program and put their money where their mouth is?

Would that have——

Mr. **Latham**. Well, it would have kept the program going. I'll put it that way. It would have completely kept the program going apparently, in terms of having the ability to build and to deploy two new Landsat satellites and the ground station in the timeframe.

Mr. **Scheuer**. That's an extremely important statement you've just made, and it seems to me a pitiful—a pitiful commentary on our ability to govern, our ability to produce the kind of joint venture that would make us a powerful leading player in space, as our national heritage and our public wants, and as you're telling me, our intelligence needs urgently require.

Mr. **Latham**. Yes, sir.

Mr. **Scheuer**. How in the world—all of you players—and I'm not making this personal——

Mr. **Latham**. Yes, sir.

Mr. **Scheuer**. But the Defense Department, Commerce, OMB, and the other users, the Agriculture Department, the Interior Department, how they could have sat fiddling while Rome burns and have not made this—not achieved some kind of consensus to find this $100 to $150 million over two or three or four years and to have required EOSAT to make agonizing cuts, desperately counterproductive cuts, requiring them to do away whatsoever with their marketing system in its entirety, and to have caused this additional loss of time, giving our global competitors—the Japanese, the French, the European Space Agency—precious time to establish a presence in space, to appropriate that commerce—for the life of me, I feel that's a terrible failure of our ability to govern ourselves.

Mr. **Latham**. Well, I don't think the final bell has rung on that yet. I hope that Mr. Carlucci and the seniors can resolve this, and I believe that's possible.

I would point out that when you look at Defense's contribution to other agencies, and particularly NOAA—there was a misstatement made earlier this morning—for example, we share all the data off the DMSP, the Defense Meteorological Satellite Program, with the civil weather industry, and we send that to them free of charge.

So a number of things are shared by us that sometimes are not acknowledged. And I agree with you, it seems like the nail in the horseshoe story——

Mr. **Scheuer**. Exactly.

Mr. **Latham**. Where you're doing something——

Mr. **Scheuer**. You couldn't have said it better.

Mr. **Latham**. So maybe it will get resolved at the senior level, sir.

Mr. **Scheuer**. I mean, this is a pitiful, tragic failure of Executive Branch leadership. You've got the Congress involved, engaged, across party lines, across cameral lines, the House and the Senate, Democrats, Republicans—we want to go for it; we want to be a major player in space. And to us, it's an agonizing experience to see us virtually abandoning the field, putting our whole program into a holding pattern while the French and the Japanese have a field day in filling that vacuum. Nature abhors a vacuum, and we have provided a pitiful vacuum in our national leadership.

Mr. **Latham**. Yes, sir. Well, for example, on one other example, though, of where we are trying to help. On the medium-lift expendable launch vehicle, a brand new program, to produce—design and produce a brand new lift-capable system for medium payloads to space.

We, the Department, have kicked that program off, held a competition. We will pay the R&D for that development of that new booster, and we, in the specifications said that that booster must be capable of also launching commercial payloads. So off the DOD production line, the commercial and, in particular, the NASA can also buy those vehicles and probably at a substantially lower cost, because it will be on viable production line, than they could otherwise.

So in that sense, that's a non-trivial DOD contribution, for example, to the civil space industry. And you add all these little pieces up, and they start to add up to a fair amount of money. And you say, "Well, how about another $100 million?"

Well, I can tell you, the Secretary said right now, he just doesn't have it, and it ought to be funded by Commerce. Now that will get, I think, thrashed out at the Cabinet level.

Mr. SCHEUER. Well, I tell you, it's extremely frustrating for us.

Mr. LATHAM. Yes, sir.

Mr. SCHEUER. And to put in in the vernacular, somebody ought to get representatives of OMB, Defense, Commerce, Agriculture and Interior into a room and lock the door and kick some butts. [Laughter.]

Do you disagree.

Mr. LATHAM. Well, if you make it at the Secretary level, that might——

[Laughter.]

Mr. SCHEUER. Secretary Latham, you have been a wonderful witness. You've said it like it is; you've let it all hang out, and you've been great.

Mr. LATHAM. I'll probably get fired, but that's all right.

Mr. SCHEUER. That's all right. [Laughter.]

Before we close, back to my co-chairman, Congressman Hall.

Mr. HALL. When they have a tail-kicking, no one wants to furnish the tail, do they? [Laughter.]

Mr. SCHEUER. Let me ask you, I'm trying to figure out what the alternatives are here and trying to glean from your testimony and your feelings exactly where we are, and then later we'll try to put it all together and see if we've made one iota of sense out of this.

Mr. LATHAM. Yes, sir.

Well, I think it's a judgment call on the Congress now. If they do see the situation as you do, that they could, you know, indicate to the Administration rather strongly the position that Congress feels on this across the party lines. I think that would be helpful to let us know and perhaps provide some direction on what to do.

Mr. HALL. If we abandon Landsat as important as it is to the Department of Defense, the CIA, the energy thrust, I'm trying to see what the alternatives are.

One, I just jotted down here that we'd probably either back away or depend on buying technology from Japan or France or someone or a joint venture with them that seems to me would make some sense, with them being a leg up on us at the present time.

Mr. LATHAM. Well, I'm not sure I agree that they're a leg up on us at all. I really don't. I mean, we—this country put up the first multi-spectral imaging system years and years and years ago, and they're Johnny-come-latelys. So I don't think they're a leg up.

Mr. **Hall**. Well, I hope you're right, but all I have to rely on—all I have to rely on is testimony that I hear from that table.

Mr. **Latham**. Well, they have put up capability in the last few months by the Japanese and last year by the French, but it's not all that startling a capability.

It's impressive to some extent, but I think we have far better technology than they do.

Mr. **Hall**. I'm glad to hear you say that.

The other would be partial funding on DOD's part, Commerce and anyone else. I guess that's up to the Congress. You're saying that's our duty, and we tell people how smart we are every two years, and we ought to solve it. That's the second alternative.

And the third that I inquired today, earlier today, of the Secretary of Commerce, I believe, if none of those—if neither of those are followed, and at the present time they're both very much in doubt and you recommend against a joint venture with Japan or France, what's the likelihood—and I ask it in this manner today of a Colonel South or a Colonel East or a Colonel West, with the CIA putting their own up, or maybe a General North, if they don't find that bank account over there anywhere—putting their own up and at a very extensive expenditure and outlay of funds?

Mr. **Latham**. I don't believe——

Mr. **Hall**. Aren't you going to do it to defend your position?

Mr. **Latham**. I don't believe we will; no, sir.

No, sir. We've discussed that internally and have made no plans whatsoever to do that.

Mr. **Hall**. I know you've made no plans, but whose to know what would happen in four or five years.

Mr. **Latham**. Well, that's possible, I guess. But right now, we said, "No, we're not going to do that," because we believe very strongly that for a very small incremental cost compared to what it would be to start all over, that you could keep this going and, in fact, put up a very capable system, so that from a national perspective, the best way ahead is to fund the current program and keep going.

Mr. **Hall**. I agree. Let me ask you this, though—and you're so forthright, and you may have an empty desk when you get back over there—but let me ask you this, and this is not—it doesn't directly relate to this, but I guess everything relates to the cash register up here, what it costs and what the price tag on it is.

MacArthur in 1945 in Tokyo Bay told the Japanese that they wouldn't make war anymore, and they said, "Okay, we'll make Sony and we'll make radio and we'll make Honda," and are they every doing it. They're doing it with the money they don't spend on defense.

How often does that treaty come up? Is that a five-year treaty that's re-acted on every five years?

Mr. **Latham**. I'm not really sure, sir. I'm not really sure on that.

Mr. **Hall**. Would it make any sense to you to give them the right to defend their own shores, and the money they spend now subsidizing their industries that cost us 3500 jobs at Lone Star Steel in Texas and then 60 percent of our total work force—we have carriers and battleships circling Honshu right this afternoon—would it make a lot of sense to you, as the spokesman for the Department of Defense?

Mr. LATHAM. Well, we have been negotiating with the Japanese, as you know, for a shared defense treaty, and, in fact, they have agreed to defend their waters out to 1000 miles from the Japanese coastline and have, in fact, frankly been stepping up to that much, much better, and their recent budget for defense actually broke through that magic 1 percent of their budget line.

So I'm encouraged that they recognize that they are, in fact, an important ally and that they are, in fact, faced with a very serious threat from the Soviet Union, and that they need to do more.

Clearly, we'd like them to do even more than they're doing now. That's no hidden fact.

Mr. HALL. We have protesters when we re-enter into the agreement, and they have the same over there. It looks like it makes sense to me.

Mr. LATHAM. Yes, sir.

Mr. HALL. To have that money to spend on matters of greater import to us and a small bit of it drop out for the Landsat program.

Mr. LATHAM. Yes, sir.

Mr. HALL. Thank you, sir.

Mr. LATHAM. Yes, sir.

Mr. HALL. Thank you, Mr. Chairman.

Mr. SCHEUER. Secretary Latham, you've been a wonderful witness.

Mr. LATHAM. Thank you.

Mr. SCHEUER. And we all respect and admire what you have to tell us.

Thank you very, very much.

Mr. LATHAM. Thank you.

Mr. SCHEUER. And we'll schedule that secure meeting later this week or next week.

Mr. LATHAM. Okay. Thank you.

Mr. SCHEUER. Thank you very, very much.

All right. We'll now go on with the next panel, the EOSAT panel: Charles Williams, President of EOSAT; Charles Schmidt, Vice President and General Manager of GE/RCA Astro-Space Division; and Warren Nichols, Director of the Hughes Santa Barbara Research Center.

We're very happy to have you here and appreciate your patience and forebearance, these hearings have run very late, but only because they have been very interesting and very thought provocative and very productive. So, we ask your indulgence. We must be out of this room by 2 o'clock. We will ask each of the three of you to give us about five minutes of testimony each. Your statements will be printed in full at this point in the record, okay.

STATEMENTS OF PETER M.P. NORRIS, EXECUTIVE VICE PRESIDENT, EARTH OBSERVATION SATELLITE CO.; WARREN NICHOLS, DIRECTOR, HUGHES SANTA BARBARA RESEARCH CENTER; AND CHARLES SCHMIDT, VICE PRESIDENT AND GENERAL MANAGER, GE/RCA ASTRO-SPACE DIVISION

Mr. Norris. Thank you, Mr. Chairman. On behalf of EOSAT and its parent organizations Hughes Aircraft and General Electric's/RCA Astro-Space Division, we are happy to appear before the subcommittee and express our concerns on the current status of the Landsat program. Speaking with me this afternoon are Mr. Nichols, as you mentioned, Vice President of Santa Barbara Research, and Mr. Schmidt, the Group Vice President of GE/RCA Astro-Space. Mr. Nichols will speak briefly about the status of the remote sensing technology today; and Mr. Schmidt will give a summary. And I would like to speak about the status of EOSAT commercialization efforts.

During the 18 months since the start of the contract EOSAT grew to a company of over 100 people. Major and secondary subcontracts for the design and construction of Landsat 6 and 7 satellite centers and supporting ground systems were entered into 40 companies, employing approximately 700 people who were aboard on our first anniversary.

On January 5, 1987, EOSAT had to notify all of its subcontractors that because of the limitation of funds, in its primary contract, it was necessary to terminate all these activities for the sensors, the spacecraft, and the ground system. As a result, all Landsat-6 and 7 development, and market development have been curtailed, and EOSAT has reduced its direct work force by half.

EOSAT, on the other hand, has made every attempt to preserve the ability to restart the program in an efficient manner. On a brighter note, Landsat-5 continues to operate nominally. On March 1st, Landsat-5 began its fourth year of operations. Based on its history and performance to date we have reasonable expectation that Landsat data will continue through the end of 1988.

The issues of continuity and commitment have been the greatest impediments to the development of the Landsat market. Private sector investors hesitate to commit funds to the young value-added industry which, by the way, includes funds providing computer hardware, analysis software and interpretation services providing information, when they have seen the administration not willing to support its own programs.

When the administration zeroed the funding for Landsat commercialization in the 1987 budget, it sent a negative message to the industry.

In addition, there are currently 13 foreign ground stations capable of receiving the Landsat signal, and delivering a wide range of products to a broad user community around the world. New Zealand and Ecuador have announced intentions to construct new stations, and the People's Republic of China is planning the construction of a second Landsat ground station.

Since the average expenditure for a ground station ranges from 10 to 15 million, and takes two to three years, these announcements represent a serious commitment and an act of faith on the part of these nations.

EOSAT has restructured its spacecraft program and launch scenario a number of times during this past year. However, we believe that the most recent program modification submitted to the Department of Commerce in February, 1987 is in keeping with the desires of the Congress and within the budget constraints imposed by the administration. We are strongly committed to the Landsat commercialization concept, and are anxious to get the program back on its feet. We would be happy to work with the Congress and the administration to accomplish a program restart.

[The prepared statement of Mr. Peter M.P. Norris follows:]

Statement of

Peter M.P. Norris
Executive Vice President

Earth Observation Satellite Company

Before the

Subcommittees on Natural Resources, Agriculture Research and Environment; and International Scientific Cooperation
Committee on Science, Space and Technology
House of Representatives

31 March 1987

Mr. Chairmen and members of the subcommittees:

On behalf of EOSAT and its parent organizations, Hughes Aircraft Company and General Electric's RCA Astro-Space Division, we are happy to appear before the subcommittees and express our concerns on the current status of the Landsat program. Speaking with me this morning are Mr. Nichols, Vice President of the Hughes Santa Barbara Research Center in Goleta, California, and Mr. Schmidt, the Group Vice President of GE's RCA Astro-Space Division in Valley Forge, Pennsylvania. Both gentlemen are members of the EOSAT Executive Committee and will be making comments to the committee.

Status of EOSAT Commercialization Efforts

On September 27, 1985, pursuant to authority of Titles II and III of Public Law 98-365, EOSAT entered into a contract with the Department of Commerce to operate the existing Landsat System to market the data generated by the Landsat satellites, and to design, develop, deploy and operate a new generation of Land Remote-Sensing satellites. During the 18 months since the execution of the contract, EOSAT has grown from a small nucleus consisting of a handful of key personnel to over 100 people directly working in the administration, management and marketing of the Landsat resource. Major and secondary subcontracts dealing with the design and construction of the Landsat 6 and 7 satellites, sensors and supporting ground systems were entered. Forty companies, employing approximately 700 people, were involved in the new Landsat development program by our first anniversary.

On January 5, 1987 EOSAT notified all of its subcontractors that because of limitation of funds in its primary contract, it was compelled to terminate all development activities for Landsat 6 and 7, future sensors, and the ground system. As a result, all Landsat 6 and 7 development and market development have been curtailed, and EOSAT reduced its direct work force by half.

EOSAT has made every attempt to preserve the ability to restart the program in an efficient manner. For example, at the time of shutdown 80% of the Thematic Mapper (TM) drawings had been completed, and 90% of the material ordered and sub assemblies poised to start. These accomplishments will enhance our ability to restart.

Landsat Program Status

On a brighter note, Landsat 5 continues to operate nominally. On March 1, Landsat 5 began its fourth year of operations. Based on its history and performance to date we have reasonable expectations that Landsat data will continue through the end of 1988. Under the terms of the original contract we would have been prepared to launch Landsat 6 in December 1988, minimizing any gap in data service. If we can restart the program this summer, we can expect a launch in June 1990. This will result in a potential disruption in data services for an 18 month period.

The question of data continuity and the apparent lack of U.S. commitment to land remote sensing have caused confusion in the industry and have resulted in wide spread disruption of services to the user community. The issues of continuity and commitment have been the greatest impediments to the development of the Landsat market. Private sector investors hesitate to commit funds to the young value-added industry (which include firms providing computer hardware, analysis software, and interpretation services), when they see the Administration not willing to support its own programs. The passage of P.L. 98-365 and the award of the commercialization contract signaled a change in policy and shift toward support of the program. However, when the Administration zeroed the funding for Landsat commercialization in the Fiscal 87 budget, it sent a negative message to the industry.

The competitive advantage that Landsat currently possesses globally is a result of 15 years as the only source of high resolution, multi-spectral land remote sensing data. Approximately thirty percent of the Landsat data shipped from the EROS Data Center in Sioux Falls, South Dakota are directed to our international clientel. In addition, there are currently 13 foreign ground stations capable of receiving the Landsat signal and delivering a wide range of products to a broad user community around the world. In September 1985, there were 11 stations and only 7 could receive the Thematic Mapper (TM) data. After the U.S. approval of the EOSAT contract, the other ground stations have made commitments to upgrade for Landsat reception. In addition, New Zealand and Equador have announced intentions to construct receiving stations, and the People's Republic of China is planning the construction of a second Landsat ground station. Since the average expenditure for a ground station ranges from $10 to $15 million and takes two to three years to bring on-line these announcements represent a serious commitment and act of faith on the part of these nations. Needless to say, current funding problems faced by EOSAT raise serious doubts in the minds of our foreign partners regarding the U.S. Government's continuing support for Landsat.

A key element of EOSAT's development plans for Landsat 6 and 7 include enhancing the Thematic Mapper sensor through the addition of a 15-meter panchromatic band to the seven spectral band suite currently available. Since the pan band will be co-registered, users will be able to easily utilize high spatial resolution information necessary for precision mapping together with the high quality spectral data which is required to derive information about earth resources. Currently, only Landsat is capable of providing data in the short wave infrared region of the spectrum, an area critical for differentiation of certain geological mineral zones, hydrocarbon seepage areas, and vegetative condition. With the increasing availability of TM data since 1985, we are just beginning to learn about the full potential of the short wave infrared data. No other operating or planned earth observing satellite system will be able to deliver a co-registered data set of this caliber.

Last spring NASA and EOSAT organized a workshop of leading experts in thermal infrared sensing technology to consider the value of multi-band thermal measurements from Landsat and to define requirements for such a sensor. Based on the findings of their report, EOSAT and NASA are discussing the means to incorporate the thermal infrared (TIR) bands in the ETM instrument to fly on Landsat 6. The addition of four 60-meter

TIR bands to the ETM will mean that Landsat 6 will be the most advanced earth observing satellite operating capable of producing a broad range of data to satisfy both operational requirements and the data needs for the research and scientific communities.

A similar meeting involving experts from the ocean sensing community was organized by NASA and EOSAT in February 1987 to assess the potential and requirements for an ocean color instrument on Landsat 6. The results from this meeting are just being circulated for review and will most likely conclude with the recommendation to fly an ocean specific sensor as a compliment to the ETM. The availability of this data type will open up new markets for remotely sensed data and will make Landsat more valuable to a wider user base.

Landsat Program Future

1986 was a difficult year for the U.S. space program. Loss of the Shuttle Challenger in January followed by ELV launch failures has placed the entire program in turmoil. EOSAT has restructured its spacecraft program and launch scenario a number of times during this past year. However, we believe that the most recent program modification submitted to the Department of Commerce in February, 1987 is in keeping with the desires of the Congress and within the budget constraints imposed by the Administration. We are strongly committed to the Landsat commercialization concept and are anxious to get the program back on its feet. We would be happy to work with the Congress and the Administration to accomplish a program restart.

We await direction.

This completes my prepared remarks, Mr. Chairmen.

Mr. SCHEUER. Thank you very much.

Mr. Nichols.

Mr. NICHOLS. Good afternoon, gentleman. I'd like, first of all, to announce I have a minor logistical problem. I was planning to be able to use the viewgraph projector system with a few selected charts from my written material. It still seems possible we might have that capability.

We have submitted a written package of material addressing the specific question, what are the possible remote sensing technologies for Landsat 6 and 7. We have provided a bit of background there addressing, first of all, what our recommendations are; our perspective of what our competition, specifically the French and Japanese, are doing and what they are proposing; and then, I think, importantly, trying to provide some perspective on the thinking that we put in to our recommendations. These recommendations are not arrived at in a trivial way; they have been the result of study since our initial proposal days in 1983.

They are under a process of continual refinement. We do have a series of sensor opportunities, sensing opportunities that we have examined. A few, we have arrived at judgment on. Some we have been working jointly with NASA; we've had a very good relationship developing with NASA over the last year or so. And I might add, also, with NOAA. And these studies are ongoing.

I think it's important to point out that as commercial venturers, in the context that we are ultimately shooting for this goal we're all talking about, namely, the commercialization of Landsat, we have to look at the program from a commercial aspect. Matters of national policy are interesting, they do not necessarily translate the bottom line dollars.

We, therefore, are looking at all of the sensing possibilities, but we are particularly focusing on those which have commercial reward; and that's an important distinction. It is, if you will, a subset of the total class of things to be sensed.

Those which have commercial potential warrant further and more detailed review, and are in the process of getting it.

It doesn't appear that I'm going to be able to have these viewgraphs, so let me try to proceed as best I can.

First of all, in the arena of things to be sensed, we see three major market segments, a number of minor segments which fall from those, but three major ones.

First, a wide field, i.e., 90 degree field of view from the satellite, low resolution, rapid revisit sensor. This stems from experience in the MEDIASAT arena. And the sensors we're talking about here are of primary interest, both to the ocean sensing community and to the renewable resource community. We see opportunities there for revenue for EOSAT, for Landsat by providing these wide field low resolution centers targeted at specific market segments.

At the next stage, next major segment we see a need for a synoptic moderate resolution sensing system, of the sort of thematic mapper or enhance thematic mapper. This is the baseline system that we're operating with; we think it must continue.

Finally, we see a need for, and this is an element of our original proposal to Commerce, we see a need for custom targeting, and a high resolution capability. This is the French spot system, as it now exists, improved in some respects, a MEDIASAT could grow from that capability, and, of course, a more elaborate advanced Landsat could also grow from that capability.

So, three levels; low resolution, the moderate resolution, the 30 meter, 15 meter Landsat today, and a custom targeting narrow field of view, high resolution sensor which would have significant markets as well.

Mr. SCHEUER. Excuse me, Mr. Nichols. The screen is there, and apparently the technology is there; do you want to use it?

Mr. NICHOLS. I'd be delighted to.

Mr. SCHEUER. OK.

Mr. NICHOLS. This is where I have to go to pictures.

Thank you for your forebearance here.

By way of background, I would like first to point out that there are several dimensions to remote sensing. I'm sure some of you are aware of this. And one of the most important ones is to get the picture in focus.

What you have across the ordinate is the spectro wave length. The visible band is down under one micrometer. That's where SPOT 1 and 2 are focused. It's also, of course, the operating region for Landsat at this time; and Landsat does extend beyond that. The shortwave IR.

The thing of interest here is the wide range of information that's available spectrally out there that people aren't really reaching for yet, both in the reflected energy, data set on the left, and then the thermally radiated data set on the right, there's a great deal of new information which is available, which can be developed into marketable products we believe.

In the context of Landsat the thematic mapper, we have already made a proposal to begin to expand on the thermal IR. You'll notice the thermal IR option over there, that is currently an issue that we are exploring with NASA may in fact develop a joint program with them on.

The advanced Landsat sensor which we originally proposed is focused primarily in the visible and shortwave IR spectrum, but adds a great many bands and allows us to do the beginning of spectrometry in those bands; and that, in addition, provides a great deal of information.

MEDIASAT, these wide field sensors, the Japanese ERS-1, also concentrate on the visible and shortwave IR spectrum.

Interestingly enough, the most recent data on the Japanese ERS-1 is that they may in fact have backed away from the longwave IR and mediumwave IR measurements that they were originally proposing.

The point, however, is that, there's a lot of information out there and we really are just beginning to scratch the surface of what can be measured, and what could possibly be brought to market.

Moving right along.

Mr. SCHEUER. Could you tell us in laymen's terms where the Japanese are in comparison to where we are? Are they ahead of us; are they behind us; are they catching up?

Mr. NICHOLS. We think they're slightly behind us in technology. The sensor they propose is a 20 meter special resolution sensor with quite good spectral agility, it will be very competitive in its time period in the early '90s. We could also do that. We're doing something closely approximating that with enhanced thematic mapper. So, it will be on a par.

These systems have a gestation period of five to seven years, if you don't allow for the funding process that has to run before that. So, we're talking about decisions now that will affect what we do in the mid-'90s and beyond. We're beginning to lose ground there, sir.

Mr. SCHEUER. And what has been the effect of the interruption in the funding?

Mr. NICHOLS. It hasn't helped at all.

Mr. SCHEUER. And how much further has it put us behind the eyeball?

Mr. NICHOLS. Pretty much day for day.

Mr. SCHEUER. Being competitive?

Mr. NICHOLS. I think in terms of market development, we've lost our first year because of the impediments which we've had to work under. In terms of technology, we have moved ahead until January on the development of the Landsat sensor, and on the spacecraft; those are stalled now and we are losing time.

This is a very important point I'm trying to make here. If we presume that a data set is available at launch, for example, of Landsat-4, 1982, mid-1982, what I'm suggesting to you is that five years later approximately, we're just beginning to get past the knee of curve on application development. The science necessary in order to expand the market and get people to use the product.

The time that it takes to take a data set from Landsat, do the applications development work, so that there's a broad spectrum of users who can make productive economic use of the data is about five years. After that five years, we begin to see a growth in the market sales. So, we're looking at a 10 year span between the introduction of a new data set and its full economic utility. That's an important point to keep in mind. We've tested that. We've seen that happen on MSS. We've now seen it begin to happen on Landsat. So, we still have some economic growth ahead of us, just in the thematic mapper.

There is at least a 10-year cycle that we're dealing with here in terms of developing the system, flying it, getting the applications technology straightened out, and then finally going to market with it in a big way, and making it have payoff.

This is the scale of time that we have to talk about in this business.

Mr. SCHEUER. When you say, going to market in a big way, when the foreign purchasers—when purchases around the world, both in our country and out of our country, see the ambivalence in our government toward this whole enterprise, and see the stop and go, the huff and the puff, and the one step forward and two steps backward approach that our government is taking.

Doesn't it mean that when we finally develop the technology, and we finally get it up there, and we finally start to sell, we're going to find that sell a much tougher sell.

Mr. NICHOLS. We're certainly encouraging competition, sir. And we are doing that for sure. And that's going to be more inertia, more impediment for us to overcome in the future.

Mr. SCHEUER. We're not only encouraging the competition to go for it, and to feel that they've got a free field, but aren't we also discouraging foreign purchasers, at whatever time we may be coming to them with our new product and our new services, and our new market enterprise. Aren't we going to make it much more difficult for that marketing capability to actually sell, based on our past, lackluster performance.

Mr. NICHOLS. We are certainly going to make it more difficult for us to sell; there's no question about that.

On the plus side, the technology that we have with the thematic mapper is still winning us new customers in the presence of SPOT. We're losing relative position, but we're still moving ahead. Our sales this last two months have been ahead of where they were a year ago, which is definitely heartening; not a lot, 10 percent, but we're making progress. We could have made more progress in the past year.

Mr. SCHEUER. Sure. Do you have any information what level of sales SPOT and the Japanese system is capable of producing and are producing in comparison to our sets? In other words, are they catching up; are they passing us? You said you've had a modest increase in sales. Have they had a modest increase or a substantial increase?

Mr. NICHOLS. Well, the French have gone from flat zero to perhaps 30 to 40 percent of the market in the time that they've been flying, and that's not bad.

The Japanese, of course, have nothing to sell at this time. But they are actively developing, they're doing their homework. I'm not sure the Japanese are going to come into the market as data purveyors, they may use the data in a different way.

Mr. SCHEUER. They may what?

Mr. NICHOLS. They may use the data in a different way. They may use it as a policy tool.

Mr. SCHEUER. Until consultation services and joint venture.

Mr. NICHOLS. Yes. Third world development schemes, I think, which are quite appropriate for them really. It would be appropriate for us as well.

We have been going through a business opportunity analysis process looking at all the sensor possibilities. I'd like to share with you a little bit of what we go through.

First, we recognize that there may be an opportunity for a new sensing data set. Let's say, a set of bands of a given resolution from a given sensor.

We go through a market projection analysis of what that data set may bear. We do a preliminary design requirement statement to look at what the sensor design might be. We look at the cost of that. We do a preliminary cost and business analysis.

Then what we have done in the recent past is to begin a series of user interactions, NASA in particular, and Dr. Tilford here in particular, have been very helpful to us in that regard.

A year ago we sponsored a joint workshop on the thermal IR addition to Landsat, and we really had quite a success with that. It allowed us to define rather accurately what the system design requirements for that feature should be.

We then go through further analysis that lead into a final business decision. And that process is still under way, and in fact, has been impeded by this turmoil that we've been in.

Mr. Scheuer. Mr. Nichols, we're operating under a terrific time pressure now, we've gone way over. This is not your fault, it's our fault. Its been an extremely interesting morning, and your testimony is very interesting, but I'm forced by the time constraints to suggest that you sort of bring your testimony to a close so that we can have a chance to answer questions.

Mr. Nichols. Two more quick charts. This one which shows what our specific recommendations are, both for Landsat-6 and for Landsat-7. We've allowed for two possibilities on 7, one being the same basic spacecraft and launch capability that we have on 6; and the other being for a more robust system. And we have identified this material, and it's certainly available in the package we've given you for your reading.

Last and also quite important, the relative importance in terms of revenue and we have provided this chart and the numbers to go with it to your staff, by the way, for the various sensing opportunities that we postulated, starting with the thermatic mapper, which of course is the system baseline moving into the thermal IR package, which was proposed, looking at the ocean sensing, wide field sensing capability, all put together and flying on LANDSAT-6. We believe there is considerable revenue potential in those.

These other capabilities add on with LANDSAT-7 in the scheme we are proposing.

These are primarily provided to show relative order of magnitude revenue potential from the various sensing opportunities.

I think the point here is that one of the major thrusts we have at EOSAT is to broaden our product base in order to have more products to sell to a broader user segment.

Thank you very much.

[The prepared statement of Mr. Warren Nichols follows:]

ISSUE: WHAT ARE THE POSSIBLE REMOTE SENSING TECHNOLOGIES FOR LANDSAT 6 AND 7?

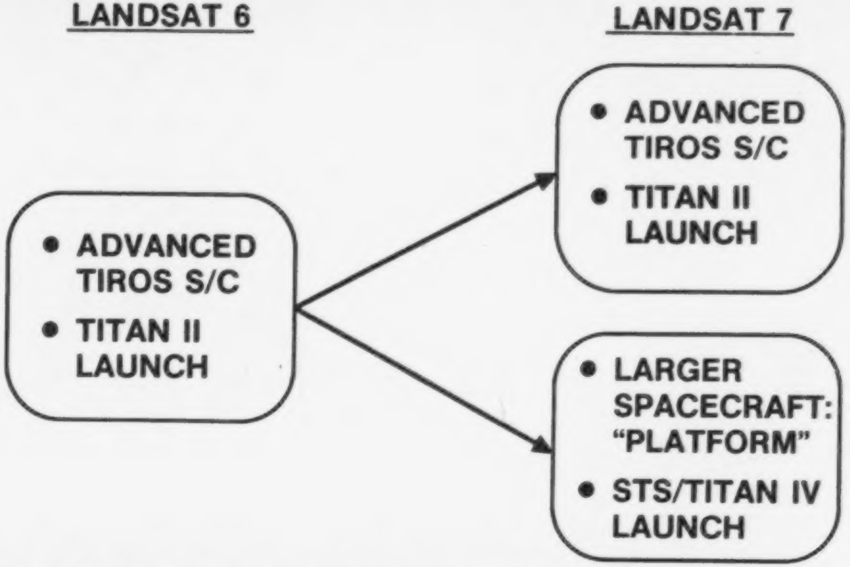
Expanding Man's
Knowledge of the
Earth's Resources

- ANSWER:
  - EOSAT'S RECOMMENDATIONS
  - WHAT THE COMPETITION IS DOING (OR PROPOSING)
  - BASIS FOR EOSAT'S RECOMMENDATIONS
    - BACKGROUND FACTORS
    - OPPORTUNITY ANALYSIS PROCESS
    - STATUS OF EOSAT'S APPLICATION OF THE OPPORTUNITY PROCESS

EOS

SPACECRAFT AND LAUNCH ALTERNATIVES LEAD TO THREE CANDIDATE PAYLOAD SETS

Expanding Man's
Knowledge of the
Earth's Resources



LANDSAT 6

- ADVANCED TIROS S/C
- TITAN II LAUNCH

LANDSAT 7

- ADVANCED TIROS S/C
- TITAN II LAUNCH

- LARGER SPACECRAFT: "PLATFORM"
- STS/TITAN IV LAUNCH

- LARGER PAYLOAD CAPACITY OF L7 "PLATFORM" CONFIGURATION SUPPORTS MORE SENSORS AND DATA HANDLING EQUIPMENT

Earth Observation Satellite Company

3/87
70620-3

PAYLOAD RECOMMENDATIONS
BASED ON PERCEIVED CUSTOMER NEEDS

- SEVERAL IMPORTANT MARKET SEGMENTS:
  - WIDE-FIELD, LOW RESOLUTION
    - RAPID REVISIT
    - SEVERAL SUB-CLASSES: OCEAN, LAND, R&D SPECTROMETRY
  - SYNOPTIC, MODERATE RESOLUTION
    - PERIODIC GLOBAL COVERAGE
    - THEMATIC MAPPER/ENHANCED THEMATIC MAPPER CLASS
  - CUSTOM TARGETING, HIGH RESOLUTION
    - ADVANCED LANDSAT SENSOR (ALS): DETAILED SPATIAL/SPECTRAL/RADIOMETRIC DATA
    - MEDIASAT: HIGH SPATIAL RESOLUTION, NEAR-REAL-TIME MODE FOR NEWS GATHERING

LANDSAT 6 PAYLOAD SHOULD INCLUDE ETM WITH TIR AND OCEAN COLOR IMAGER

Expanding Man's
Knowledge of the
Earth's Resources

- BASELINE SENSOR: ENHANCED THEMATIC MAPPER (ETM)
  - 6 BANDS IN VISIBLE, NEAR INFRARED, SHORTWAVE INFRARED @ 30M
  - 1 PANCHROMATIC VISIBLE BAND @ 15M
- MULTISPECTRAL THERMAL INFRARED (TIR) OPTION DEFINED, READY FOR INCORPORATION
  - 1 MIDWAVE INFRARED BAND @ 120M, 4 LONGWAVE @ 60M
  - SCIENTIFICALLY SIGNIFICANT NEW DATA SET AT MINIMAL COST
  - NASA/EOSAT COOP PROGRAM DEFINED
  - POTENTIAL COMMERCIAL APPLICATIONS AS WELL
- COMPACT WIDE-FIELD SENSOR (CWIFS) FOR OCEAN-COLOR DATA
  - WIDE SWATH, RAPID REVISIT FOR OCEAN/COASTAL DATA
  - SERVES NAVY, OCEAN INDUSTRIES, NASA, ACADEMIA
  - JOINT WORKING GROUP ENCOMPASSING ALL PARTIES CONVENED IN FEBRUARY; RECOMMENDATIONS AND PROGRAM PLAN TO BE PUBLISHED

Expanding Man's
Knowledge of the
Earth's Resources

L7 TIROS/T2 PAYLOAD LIMITED BY LAUNCH CAPACITY; MEDIASAT SENSOR MAY FIT WITHIN WEIGHT MARGIN

- LANDSAT 6 SENSOR COMPLEMENT CARRIED FOR CONTINUITY
  - ETM WITH TIR
  - cWIFS FOR OCEAN COLOR DATA
- MODIFIED cWIFS FOR RENEWABLE RESOURCES
- MEDIASAT SENSOR OPENS NEW MARKET OPPORTUNITIES
  - 5M SPATIAL RESOLUTION, 17 KM SWATH, RED/GREEN/BLUE BANDS
  - DIRECTLY COMPATIBLE WITH ETM DATA RATE
  - POTENTIAL APPLICATIONS FOR URBAN PLANNING, DETAILED CARTOGRAPHY, AS WELL AS NEWS GATHERING
  - LEGAL AND NATIONAL SECURITY ISSUES BEING STUDIED

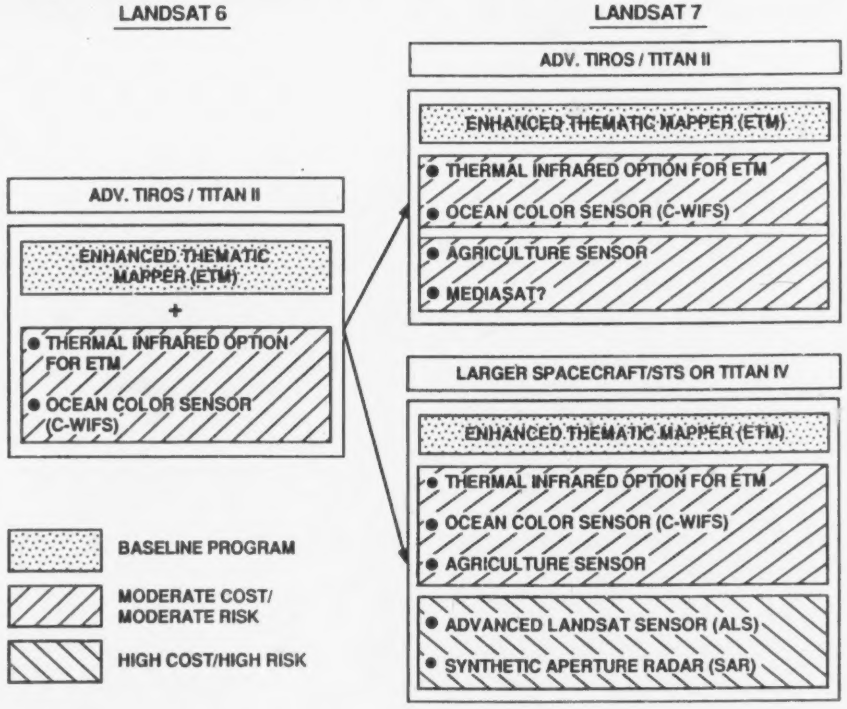
LANDSAT 7/PLATFORM PAYLOAD SHOULD SERVE FULL SPECTRUM OF LANDSAT CUSTOMERS

Expanding Man's
Knowledge of the
Earth's Resources

- LANDSAT 6 SENSOR COMPLEMENT CARRIED FOR CONTINUITY
  - ETM WITH TIR
  - CWIFS FOR OCEAN COLOR DATA
- ALS/MEDIASAT SENSOR FOR HIGH-RESOLUTION CUSTOM DATA
  - 10/20M SPATIAL RESOLUTION IN 8 VNIR/SWIR BANDS
  - 5M RGB MODE FOR MEDIASAT
  - CROSS-TRACK POINTING FOR RAPID ACCESS
- WIDE-FIELD LAND SENSOR FOR LAND OBSERVATION
  - cWIFS SWATH, SPATIAL RESOLUTION WITH ETM BAND SET
  - COMPLEMENTS ETM FOR AGRICULTURAL/RENEWABLE RESOURCE MARKET
- POSSIBLE VEHICLE FOR RADAR (SAR)

SENSOR SUITE RECOMMENDATIONS FOR LANDSAT 6 AND LANDSAT 7

Expanding Man's
Knowledge of the
Earth's Resources



LANDSAT 6

ADV. TIROS / TITAN II

ENHANCED THEMATIC MAPPER (ETM)

+

- THERMAL INFRARED OPTION FOR ETM
- OCEAN COLOR SENSOR (C-WIFS)

LANDSAT 7

ADV. TIROS / TITAN II

ENHANCED THEMATIC MAPPER (ETM)

- THERMAL INFRARED OPTION FOR ETM
- OCEAN COLOR SENSOR (C-WIFS)
- AGRICULTURE SENSOR
- MEDIASAT?

LARGER SPACECRAFT/STS OR TITAN IV

ENHANCED THEMATIC MAPPER (ETM)

- THERMAL INFRARED OPTION FOR ETM
- OCEAN COLOR SENSOR (C-WIFS)
- AGRICULTURE SENSOR
- ADVANCED LANDSAT SENSOR (ALS)
- SYNTHETIC APERTURE RADAR (SAR)

░	BASELINE PROGRAM
▨	MODERATE COST/ MODERATE RISK
▧	HIGH COST/HIGH RISK

3/87
70620-1

Earth Observation Satellite Company

FOREIGN COMPETITION IS MOVING AHEAD

Expanding Man's
Knowledge of the
Earth's Resources

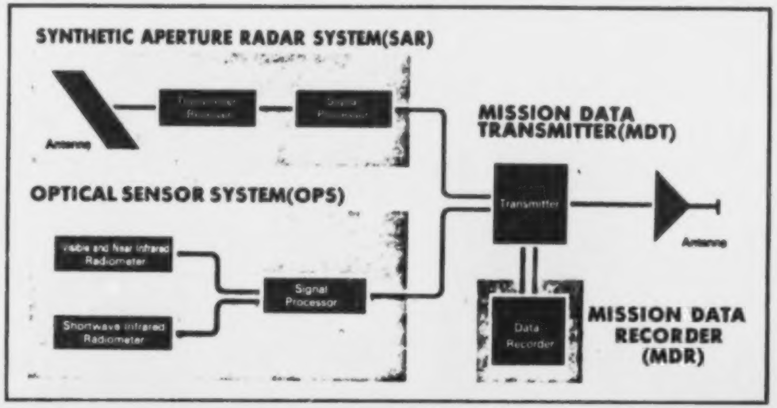
- FRANCE: SPOT REMOTE SENSING SATELLITE
  - 10/20 METER RESOLUTION, 60 KM SWATH, MULTISPECTRAL/STEREOSCOPIC DUAL "PUSHBROOM" SENSORS
  - SCENE AREA EQUALS 11% OF ENHANCED THEMATIC MAPPER
  - FIRST LAUNCH OCCURRED ON FEBRUARY 21, 1986
  - 2 ADDITIONAL SPACECRAFT UNDER CONTRACT
  - WORLDWIDE NETWORK OF GROUND STATIONS AND DATA SALES AGENTS/AFFILIATES
  - SPOT 4 TO INCLUDE LOW RESOLUTION RENEWABLE RESOURCE INSTRUMENT (MID-1992 LAUNCH EXPECTED)
  - EXPECTED COSTS FOR SPOT 4/5 SPACECRAFT AND LAUNCHES IS $460M

FOREIGN COMPETITION IS MOVING AHEAD (CONTINUED)

Expanding Man's
Knowledge of the
Earth's Resources

- JAPAN: EARTH RESOURCES SATELLITE 1
  - 18 METER RESOLUTION, 75 KM SWATH, MULTISPECTRAL/ STEREOSCOPIC "PUSHBROOM" OPTICAL SENSOR PLUS 18 METER RESOLUTION SYNTHETIC APERTURE RADAR (SAR)
  - SCENE AREA EQUALS 17% OF ENHANCED THEMATIC MAPPER
  - FIRST LAUNCH SCHEDULED FOR FEBRUARY 1991, DESIGN DEVELOPMENT INITIATED IN 1984
  - LAUNCH VEHICLE (H1 ROCKET), SPACECRAFT, RADAR AND OPTICAL SENSORS ARE IN COUNTRY DEVELOPED HARDWARE

OBSERVATIONS SYSTEMS FOR EARTH RESOURCES SATELLITE — 1


SYNTHETIC APERTURE RADAR SYSTEM(SAR)
Antenna
Transmitter Receiver
Signal Processor
OPTICAL SENSOR SYSTEM(OPS)
Visible and Near Infrared Radiometer
Shortwave Infrared Radiometer
Signal Processor
MISSION DATA TRANSMITTER(MDT)
Transmitter
Antenna
Data Recorder
MISSION DATA RECORDER (MDR)

MISSION DATA TRANSMITTER (MDT)

The MDT sends the real-time observation data from SAR and OPS or recorded observation data by MDR to the ground, using a 8 GHz band carrier. This transmitter has two carrier frequencies within the range from 8,025 to 8,400 MHz.

CHARACTERISTICS OF MDT	
Frequency	8,025-8,400 MHz, 2 channels
Modulation	QPSK
Data rate	60 Mbps/1 channel
Power amplifier	TWT (Helix type)
RF output	20W
Antenna type	Shaped reflector beam antenna

MISSION DATA RECORDER (MDR)

The MDR records the high-speed observation data (30 Mbps × 2) furnished from the SAR and OPS and reproduces the recorded data over the ground station.

CHARACTERISTICS OF MDR	
Recording data rate	[illegible]Mbps × 2ch
Recording time	20 min.
Operating time	1,000 hrs. (max.)

SYNTHETIC APERTURE RADAR SYSTEM (SAR)

The SAR is an active microwave imaging radar achieving high resolution in realistic antenna dimensions as a spaceborne antenna by the synthetic aperture technique.

The SAR has following features.

1) Having remarkable high resolution.

2) Capability of operating all day and in all weathers.

The SAR is composed of an antenna, a transmitter/receiver and a signal processor.

CHARACTERISTICS OF SAR	
Frequency	1275MHz
Polarization	H-H
Off-nadir angle	35deg
Resolution	
Range	18m
Azimuth	18m(in 3Looks)
Swath width	75km
Noise equivalent σ°	-20.5dB max.
S/A	14dB min.
Quantization	3bits
Output data rate	60Mbps

OPTICAL SENSOR SYSTEM (OPS)

The OPS is a multispectral imaging radiometer with high geometric resolution.

The OPS has the following features:

1) Observing in many optical wavelength regions from visible to shortwave infrared.

2) Having high resolution for accurate observation.

3) Capable of taking stereoscopic image data and multispectral image data at the same time.

4) High reliability and compactness with [illegible] [illegible] using charge-coupled devices (CCD) with [illegible] [illegible].

The optical sensor consists of a visible and near infrared radiometer, a shortwave infrared radiometer and a signal processor.

CHARACTERISTICS OF OPS	
Number of observation bands	3 visible and near infrared bands 1 stereo-vision band 4 shortwave infrared bands
Resolution	18.3m × 24.2m
Swath width	75km
Quantization	6bits
Output data rate	60Mbps
Base height ratio in [illegible]	0.3

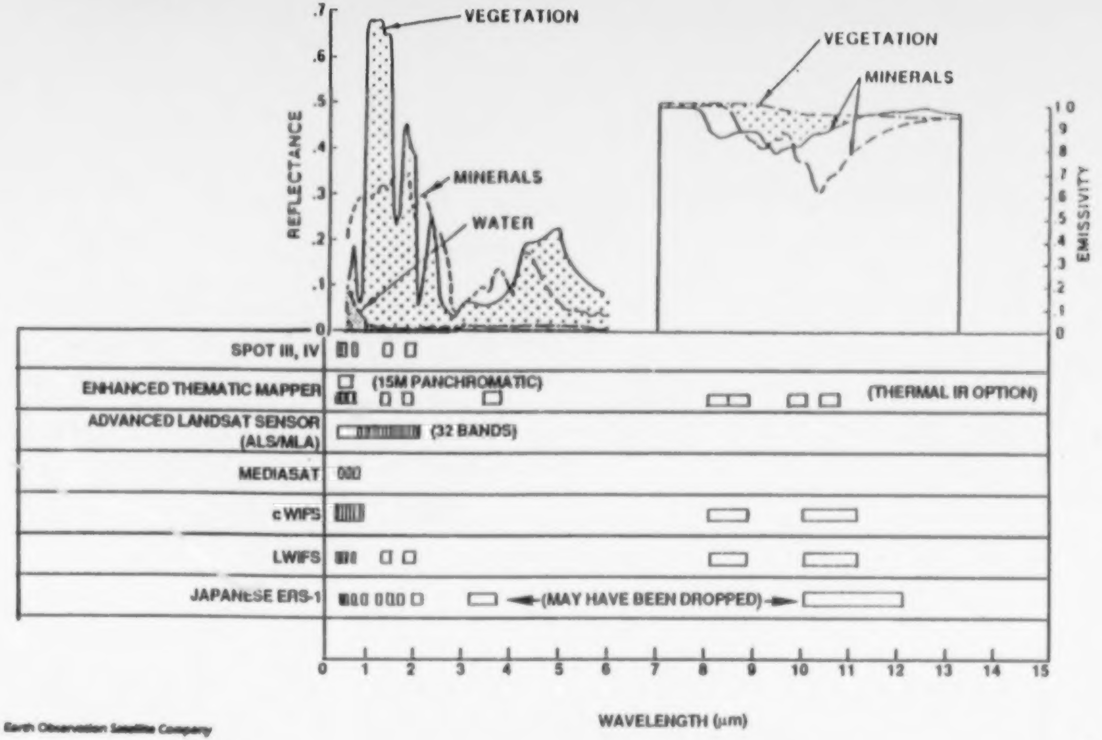
BASIS FOR EOSAT'S RECOMMENDATIONS — BACKGROUND FACTORS

Expanding Man's
Knowledge of the
Earth's Resources

- INTERRELATION BETWEEN SCIENTIFIC (READ NASA) AND APPLICATIONS (READ EOSAT) OBJECTIVES:
  - AVAILABLE DATA SPECTRUM
  - TIMELINE FOR TRANSITION — SCIENCE — APPLICATION DEVELOPMENT — COMMERCIAL OPERATIONAL MARKET
- NATURAL SYSTEM CONSTRAINTS WHICH *MUST* APPLY FOR TRUE COMMERCIALIZATION
  - CAPITAL COST (LOW COST/RISK)
  - OPERATIONS COST (HIGH EFFICIENCY)
  - PROJECTED MARKET(S)
  - ASSURED CONTINUITY

SPECTRAL RESOLUTION: KEY TO THE FUTURE

Expanding Man's
Knowledge of the
Earth's Resources



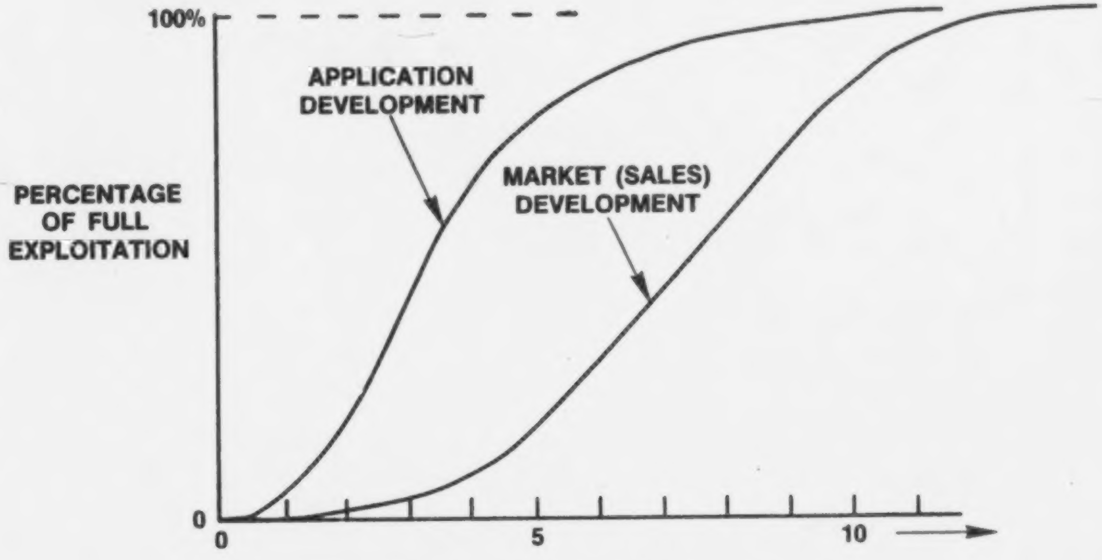
Earth Observation Satellite Company

3/87
70820-11

EOSAT

TYPICAL PRODUCT USE GROWTH CURVES — BASED ON MSS/TM EXPERIENCE

Expanding Man's
Knowledge of the
Earth's Resources



TIME — YEARS AFTER DATA SET IS AVAILABLE

3/87
70820-12

Earth Observation Satellite Company

BACKGROUND FACTORS — POSSIBLE SENSOR DESIGN FEATURES

Expanding Man's
Knowledge of the
Earth's Resources

- LOW COST/RISK:
  - WIDE FIELD, LOW RESOLUTION, MULTISPECTRAL SCANNERS
  - THERMAL IR PACKAGE
- HIGH COST, MODERATE RISK
  - ENHANCED THEMATIC MAPPER
  - "MEDIASAT" CLASS NARROW FIELD, LIMITED SPECTRUM, HIGH RESOLUTION
- HIGH COST/RISK
  - ADVANCED LANDSAT SENSOR (ALS)
    - MODERATE FIELD-OF-VIEW (5 TO 7 DEGREES)
    - RAPID (1 TO 2 DAYS) REVISIT
    - SPECTRAL FLEXIBILITY
    - OPTION FOR SAME-ORBIT STEREO
    - MODERATE TO HIGH RESOLUTION
  - RADAR
  - IMAGING SPECTROMETERS

OPPORTUNITY ANALYSIS PROCESS

Expanding Man's
Knowledge of the
Earth's Resources

- STARTS WITH RECOGNITION OF REMOTE SENSING OPPORTUNITY
- CONSISTS OF ITERATIVE STEPS:
  - MARKET PROJECTION/ANALYSIS
  - PRELIMINARY DESIGN REQUIREMENT DEFINITION
  - PRELIMINARY COST/BUSINESS ANALYSIS
  - EXTENSIVE USER INTERACTIONS
    - NASA
    - PRIVATE SECTOR — VALUE ADDED INDUSTRY
    - FOREIGN
    - UNIVERSITY
    - DoD, OTHER GOVERNMENT AGENCIES
  - REFINED SYSTEM DESIGN REQUIREMENTS
  - REFINED MARKET ANALYSIS
  - UPDATE CAPITAL/OPERATIONS COSTS
  - BUSINESS ANALYSIS/DECISION

3/87
70620-14

Earth Observation Satellite Company

STATUS OF EOSAT'S APPLICATION OF THE OPPORTUNITY PROCESS

Expanding Man's
Knowledge of the
Earth's Resources

- THERMAL IR PACKAGE (PROCESS COMPLETED)
  - UNIQUE DATA SET IN NEW FIELD, BUT SYNERGISTIC WITH CURRENT TM PRODUCT
  - CAN PROVIDE COMPETITIVE LEVERAGE (FOREIGN SYSTEMS CAN'T DO FOR LONG TIME)
  - APPLICATIONS SCIENCE ALMOST AT "GROUND ZERO" — MAY TAKE 10 YEARS FOR MARKET TO DEVELOP, BUT SHOULD BE STARTED
  - REASONABLE CAPITAL COST — SHOULD BE BORNE BY NASA, BECAUSE OF HIGH SCIENCE CONTENT
  - EOSAT SHOULD BEAR OPERATION'S COST, LEADING TO NASA/EOSAT CO-OP OPPORTUNITY
  - CONCLUSION: NOT NOW A GOOD STAND-ALONE OPPORTUNITY BECAUSE OF LONG MARKET DEVELOPMENT TIME, BUT WORTH TRYING AS A CO-OP

3/87
70820-15

Earth Observation Satellite Company

STATUS OF EOSAT'S APPLICATION OF THE OPPORTUNITY PROCESS

Expanding Man's
Knowledge of the
Earth's Resources

- OCEAN COLOR SENSOR (PROCESS IN MIDSTREAM)
  - STRONG MOTIVATED (BUT SMALL) USER COMMUNITY
  - PRELIMINARY MARKET STUDIES ARE ENCOURAGING
  - SYSTEM COST MODERATE, WILL FIT ON LANDSAT 6
  - FRENCH/JAPANESE WILL PROBABLY COMPETE
- WIDE-FIELD RENEWABLE RESOURCE (AGRICULTURE) SENSOR (PROCESS COMPLETE)
  - LIMITED, BUT STILL SIGNIFICANT, MARKET — PRIMARY USERS WOULD BE FEDERAL
  - DOES NOT APPEAR TO WARRANT COST/SCHEDULE RISK FOR LANDSAT 6. MAY FIT IN ON LANDSAT 7, DEPENDING ON INCREMENTAL COST
  - PRIMARY COMPETITION IS NOAA-AVHRR

STATUS OF EOSAT'S APPLICATION OF THE OPPORTUNITY PROCESS

- MEDIASAT (PROCESS STARTING)
  - INTRIGUING OPPORTUNITY — BUT SEVERAL PERILS:
    - REAL REVENUE POTENTIAL NOT KNOWN YET
    - LEGAL AND OPERATIONAL HAZARDS
  - MAY FIT ON LANDSAT 7 (TITAN II LAUNCHED) BUT ANALYSIS NOT YET DONE
  - NEWS SYNDICATE MAY BE A GOOD VEHICLE FOR THIS PRODUCT

EOSAT

STATUS OF EOSAT'S APPLICATION OF THE OPPORTUNITY PROCESS

Expanding Man's
Knowledge of the
Earth's Resources

- ADVANCED LANDSAT SENSOR (ALS) — (PROCESS NOT CONDUCTED)
  - WAS PART OF ORIGINAL COMMERCIALIZATION PROPOSAL
  - COULD FLY ON LANDSAT 7, BUT NOT COMPATIBLE WITH TITAN II LAUNCH
  - DESIGN DEFINITION STUDIES ONGOING. OVER $12M SPENT SINCE 1981 BY NASA, SBRC, OTHERS
  - HIGH INITIAL RISK/COST, NONINTEREST BY NASA, MARKET UNCERTAINTIES COMBINE TO PRECLUDE PRIVATE INVESTMENT IN THE IMMEDIATE FUTURE
  - PROBABLY REQUIRED TO STAY COMPETITIVE IN THE LONG TERM

3/87
70620-18

EOSAT

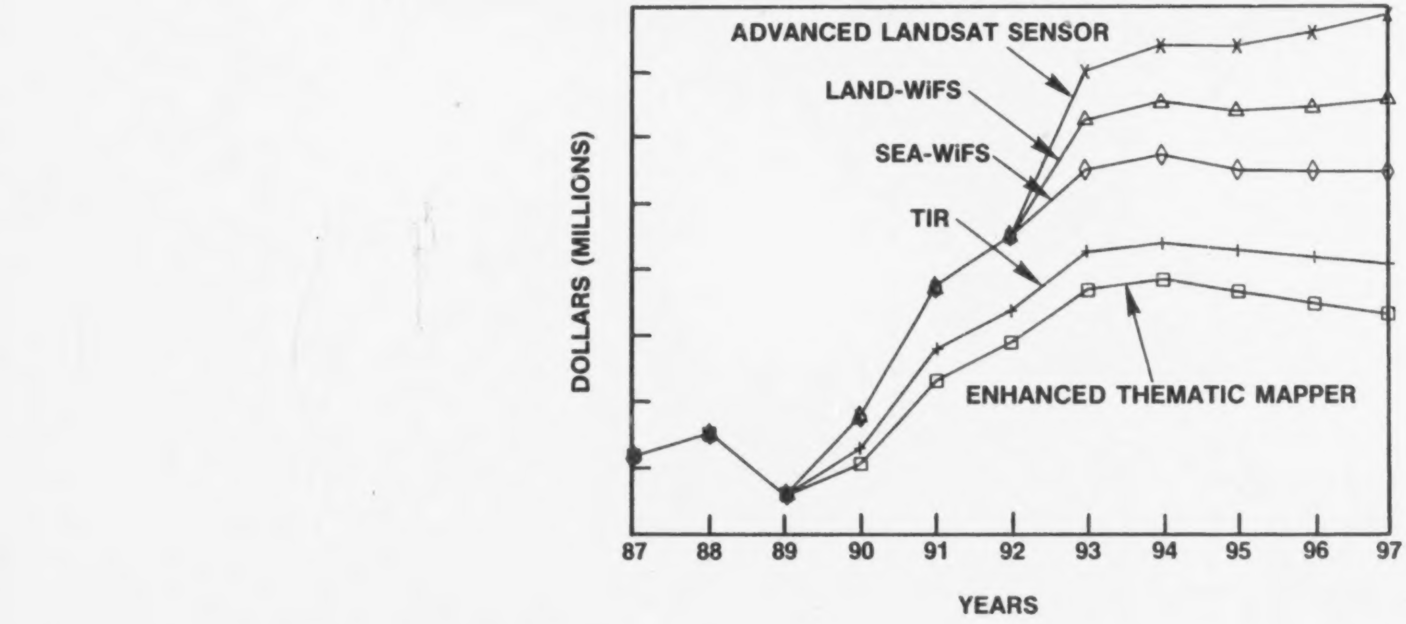
STATUS OF EOSAT'S APPLICATION OF THE OPPORTUNITY PROCESS

Expanding Man's
Knowledge of the
Earth's Resources

- SYNTHETIC APERTURE RADAR (SAR) — (STUDY PROCESS NOT CONDUCTED)
  - FUNDED PROGRAMS UNDERWAY BY ESA, CANADA, JAPAN
  - MARKET POTENTIAL REAL BUT LIMITED
  - PRODUCT TENDS TO BE COMPLEMENTARY TO OPTICAL SYSTEM PRODUCTS
  - FOREIGN CO-OP OPPORTUNITIES MAY EXIST
    - DATA EXCHANGE AGREEMENTS WITH ESA, CANADA, JAPAN, BUT ONLY IF LANDSAT OPTICAL DATA PRODUCTS ARE UNIQUE
  - NOT A COMMERCIAL INVESTMENT OPPORTUNITY AT THIS TIME

DATA SALES MARKET FORECAST BY SENSOR, 1987-1997

Expanding Man's
Knowledge of the
Earth's Resources



3/87
70820-21

Earth Observation Satellite Company

Mr. SCHEUER. Secretary Latham made it very clear that they valued that wide field sensing, land and sea, very, very much and felt that service from your satellite compared very favorably with other satellite sensing data that we have from other systems in our country and also from the French and Japanese systems.

Mr. NICHOLS. Yes, sir. To summarize my own point of view here, we can stay competitive but we have to have the will to go forward and do this.

Mr. SCHEUER. You think—I don't want to put any words in your mouth—do you think that the Office of Management and Budget ought to be locked in a room with the Department of Commerce and a few other federal departments, Agriculture, Interior, and required to come out of there with a decision, with a consensus? Answer that in your own way.

Mr. NICHOLS. We have spent a great deal of time and effort on this issue. We have been subjected from time to time to somewhat whimsical decisions and we would like very much——

Mr. SCHEUER. Did you say "whimsical?"

Mr. NICHOLS. Yes, sir.

Mr. SCHEUER. I think that's a pretty good place for it.

Mr. NICHOLS. We would like very much to clear the air and either have a swift and decent burial of this process or to unite and get on with it. We very much prefer to do the latter.

Mr. SCHEUER. And when you say "unite and get on with it," I take it you mean on a 2-satellite basis?

Mr. NICHOLS. Yes, sir. I'd like to turn this over to Mr. Schmidt at this time for his statement.

Mr. SCHEUER. Very briefly, Mr. Schmidt, with apologies.

Mr. SCHMIDT. I only have a few things to say. Mr. Chairman, members of the Subcommittee, it is somewhat ironic that we find ourselves in front of the Congress of the United States today pleading for their continued support for a program that they were so instrumental and overwhelmingly supportive in creating.

Just 2 years ago, EOSAT was embroiled in an open and fair competition to win the opportunity to commercialize the Landsat system. After an artificial and arbitrary funding limit was decreed, we were the only competitor with the experience, resources and prior investment able to undertake the principal market and technical goals of the program within that limitation.

Our program was geared toward assuming the highest probability of privatization at the end of Phase I and along these lines in the mode of a good commercial endeavor, we submitted a proposal to modify this base hardware to an in-orbit serviceable platform maintaining the same contract value. This proposal was accepted since it benefited all interested parties except the foreign competition that was imminent.

What we did not foresee was the shuttle accident and its disabling delay on shuttle dependent initiatives. Because of the enormous delay that resulted, our business could no longer remain viable and wait for the re-start of shuttle flights. The alternatives to recover were proposed and required additional funding to satisfy the new realities. Unfortunately, this became the focus of those who have been traditionally opposed to this program——

We find ourselves struggling to survive in an endeavor that is surely in the best interest of the United States Government.

I don't believe we can afford to let our shuttle disaster directly or indirectly erode our traditional and crucial role of world leadership in space technology. Our position in space leadership is indeed perishable. We have generously provided our technology to the free world. Our friendly competitors' goal with the substantial support of their governments is to supplant us as leaders, as they move swiftly into every leadership vacuum our on again, off again policies create.

These present hearings I am confident will affirm many areas of support for the continuance of a U.S. earth remote sensing resource. I want to note that at least one that our allies throughout the world will use to measure our dependability is the commitments that have been made with 13 foreign countries around the world. As Mr. Norris mentioned, they have made significant investments to facilitate for the long term availability of this data. They use it to increase the habitability of their lands and to the benefit of their people. We should not betray their trust by withdrawal.

The development of this technology required many years and much investment and the existence of a Landsat program will ensure it continues to be advanced and utilized for the overall good of the United States.

The loss of our leadership in steel, automobiles, electronics, and semiconductors should be sufficient warning as to our vulnerability. The Congress of the United States has the difficult task in this example program to show its resolve in not undermining one of the few pre-eminent positions we still enjoy.

Thank you for the opportunity.

[The prepared statement of Mr. Charles Schmidt follows:]

Statement of

Charles A. Schmidt
Vice President and General Manager
GE/RCA Astro-Space Division

Before the
Subcommittee on Natural Resources, Agriculture Research
and Environment; and International Scientific
Cooperation
Committee on Science, Space and Technology
House of Representatives

31 March 1987

Mr. Chairman and Members of the Subcommittee:

It is somewhat ironic that we find ourselves in front of the Congress of the United States today pleading for their continued support for a program that they were so instrumental and over-whelmingly supportive in creating.

Just two years ago, EOSAT was embroiled in an open and fair competition to win the opportunity to commercialize the Landsat system.

After an artificial and arbitrary funding limit was decreed, we were the only competitor with the experience, resources and prior investment, able to undertake the principal market and technical goals of the program within that limitation.

Our program was geared toward assuming the highest probability of privatization at the end of Phase I and, along those lines in the mode of a good commercial endeavor, we submitted a proposal to modify the space hardware to an in-orbit serviceable platform maintaining the same contract value.

This proposal was accepted, since it benefitted all interested parties except the foreign competition that was imminent.

What we did not foresee was the Shuttle accident and its disabling delay on shuttle dependent initiatives.

Because of the enormous delay that resulted, our business could no longer remain viable and wait for the restart of shuttle flights. The alternatives to recover were proposed and required additional funding to satisfy the new realities.

Unfortunately, this became the focus of those who have been traditionally opposed to the program and we find ourselves struggling to survive in an endeavor that is surely in the best interest of the United States government.

I don't believe we can afford to let our shuttle disaster directly or indirectly erode our traditional and crucial role of world leadership in space technology.

Our position in space leadership is indeed perishable. We have generously provided our technology to the free world. Our friendly competitors' goal, with the substantial support of their governments, is to supplant us as the leaders and they move swiftly into every leadership vacuum our on again off again policies create.

These present hearings, I am confident, will affirm many areas of support for the continuance of a U.S. Earth Remote Sensing Resource, but I want to note at least one that our allies throughout the world will use to measure our dependability.

Besides the commitments made to EOSAT for a commercialization effort, we have Memoranda of Understanding with 13 foreign governments for Landsat data availability. As Mr. Norris mentioned, they have made significant investments to facilitate for the long term availability of this data. They use it to increase the habitability of their lands to the benefit of their people. We should not betray their trust by withdrawal.

The development of this technology required many years and much investment and the existence of a Landsat program will assure it continues to be advanced and utilized for the overall good of the United States.

The loss of our leadership in Steel, Automobiles, Electronics and Semiconductors should be sufficient warning as to our vulnerability. The Congress of the United States has the difficult task in this example program to show its resolve in not undermining one of the few preeminent positions we still enjoy.

Thank you for this opportunity to express my opinions.

Mr. Scheuer. Mr. Schmidt, thank you for a very excellent statement. I don't know if you have been here all morning but I think if you had been, you would have found that the issue is not congressional resolve. The issue is the resolve of the Administration to move forward with a program that the Congress, as I have said before, across party lines, across camera lines, is enthusiastically backing. Our resolve is not in question. It's the Executive Branch resolve that is so painfully in question.

I'd like to ask all of you a question. In the March issue of Regardie Magazine, there was a story which contrasted the marketing style of EOSAT and SPOT. The tenor of the story was to the effect that EOSAT was managed by risk adverse government contractors with not much flair for marketing innovation, marketing outreach and that SPOT was managed by aggressive effective risk takers.

First of all, do you care to comment on this? Do you care to tell us whether your customers have this perception of your marketing dynamism, imagination, resourcefulness as compared to SPOT's?

Mr. Schmidt. Well, I think our problem is that our customers don't believe there is going to be a Landsat around very soon after we said there is going to be one. It's difficult for us to go and sell in a very hard way and a strong way to somebody that says, well, they just zeroed it in the budget, we had hardly got the program started.

Mr. Scheuer. I sympathize with you.

Mr. Schmidt. The French say, we are going to be in this, we have 3 satellites, we are going to launch them all, we are going to work at this for the next 20 years.

Mr. Scheuer. That is a terrible competitive disadvantage under which you are placed. There is no doubt about it.

Congressman Hall.

Mr. Hall. I think I would just want to thank them. I think they have surely shown us a broad spectrum from what is possible remote sensing technologies and then giving us a data market, sales market forecast that extends over 10 years. That is very helpful.

I guess I might ask—I personally believe we ought to pursue some type of joint venture with the Japanese. I'm not afraid to see them get technology. I'm certainly not afraid to see them rebuild even militarily because of their great bulwark against China and Russia. I like the Japanese. I guess I'll put it that way. I don't like the trade imbalance we have with them. This might be one way to approach it.

If we don't do that and apparently we have had men that know more about it than I do testify that they don't think that's particularly a good idea, but if we don't, where are you all money-wise? How much funding would EOSAT or its parent companies be willing to contribute to Landsat and under what circumstances?

Mr. Schmidt. Well, sir, I think and I hate to retreat to this, but we signed a very definitive contract as to what we were ready to do and where decision points down stream for us to make investment decisions were.

Mr. Hall. You don't bite me once?

Mr. Schmidt. I have a hard time going back and selling any more pie in the sky to my executives. I know that.

Mr. HALL. Let me ask you this; what has been the real impact of the interruption in funding the program and what do you estimate would be your re-start cost? I'm out of an energy state. Energy, the problems we have had down there, they have shut down a lot of wells like stripper wells that can't just be started back up. Is yours a similar situation? How far ahead do you have to put it in the pie plan? What are the effects, if you can tell me in about 2 minutes?

Mr. SCHMIDT. Every time there is a funding limitation—I was just here with the Energy Committee the other day on the same type of thing for SP-100—every time there is a funding slow up or change in your whole funding profile, we have to go back and re-plan and in the end, the program costs a lot more money. You might save $20 million this year but you end up paying $60 million for it 3½ years from now.

Mr. HALL. The effect of OMB continuing to delay, the effect on you and your thrust, is it fair to say it is increasing on an increasing ratio?

Mr. SCHMIDT. Yes. I think that's fair to say.

Mr. NICHOLS. I would second the motion there. In effect, it's more than day for day. In January, I was faced with the immediate requirement to re-deploy 200 people.

Mr. HALL. Thank you, Mr. Chairman. I yield back my time.

Mr. SCHEUER. Go ahead and finish.

Mr. NICHOLS. We did so successfully. Those people are gainfully employed in other things. I cannot interrupt those things now to get them re-started here in a twinkling. It is going to take time.

Mr. SCHEUER. Let me ask you the question that is of interest to many of us and that is the possibility of a joint venture with either the French or the Japanese or both in this Landsat space enterprise. They may not be interested. They may feel we have so crippled ourselves, we have so shot ourselves in the foot, that they have a competitive advantage that we will have great difficulty in playing catch up ball.

Assuming they were interested, what would your reactions be to the possibility of a joint enterprise with either the French or the Japanese?

Mr. NICHOLS. Let me field that one here. We have thought for some time there might be the possibility of cooperation at a data exchange level, particularly with the Japanese. The Japanese's primary instrument is radar. We do not have radar in our suite. It is probably not the primary system that we are working. If we have a strong position on electro-optical sensing and the Japanese have a strong position on radar, there may be a trade that can be developed there in terms of data exchange and data wholesaling and data rights.

Mr. SCHEUER. Do you feel that is a natural interface?

Mr. NICHOLS. There could be an interface there. I think it's less possible with the French.

Mr. SCHEUER. It has been an excellent panel. We very much appreciate your patience in waiting so many hours to chat with us and then giving us really important and significant testimony. Thank you very, very much.

We will now go to the last panel of the day, the federal agency panel. Shelby Tilford, Director, Earth Science and Applications Division, NASA. Michael AG Michaud, Deputy Assistant Secretary for Science and Technology Affairs, Department of State. Doyle Frederick, Associate Director, U.S. Geological Survey. James Donald, Chairman of the World Outlook Board of the Department of Agriculture.

On this last panel, we must be out of here by 2 o'clock. I deeply apologize to all of you. Let's dispense with the formal statements entirely. They will be printed in their entirety at this place in the record. We would ask each of you to discuss your agency's uses of Landsat and the importance of their purchase and the importance of Landsat to your agencies, the importance of the purchases of information from Landsat, the uses to which you put them and in general, the importance to your agencies of the integrity and the assured continuity of the Landsat surveillance system.

Let's just go from left to right, Mr. Tilford.

STATEMENTS OF DR. SHELBY G. TILFORD, DIRECTOR, EARTH SCIENCE AND APPLICATIONS DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; MICHAEL A.G. MICHAUD, DEPUTY ASSISTANT SECRETARY FOR SCIENCE AND TECHNOLOGY AFFAIRS, DEPARTMENT OF STATE; DOYLE G. FREDERICK, ASSOCIATE DIRECTOR, U.S. GEOLOGICAL SURVEY; AND JAMES R. DONALD, CHAIRMAN, WORLD OUTLOOK BOARD, DEPARTMENT OF AGRICULTURE

Mr. TILFORD. Thank you very much. I'll try to be very brief.

I think specifically if Landsat type data is not available in the future that it will be a significant——

Mr. SCHEUER. Will you talk a little louder, please.

Mr. TILFORD. There will be a significant impact to our research programs in biology, oceanography——

Mr. SCHEUER. If Landsat is what?

Mr. TILFORD. If the Landsat follow-on data is not available; geology, forestry, oceanography and many other geosciences. Landsat type data is a fundamental tool for long term research performed in many of these fields.

As you know, NASA has been one of the originators, leading proponents and supporters of the recently ICSU, International Council of Scientific Unions' program on international geosphere-biosphere global change. We have also along with the National Science Foundation supported the formation of a National Academy of Science along this line. Both of these programs require the kind of data that Landsat has been providing.

In addition, as you probably know, the Earth Systems Science Committee of the NASA Advisory Council has for the last 3 years been looking at the requirements to study the earth as a system. It's extremely important to have the kind of data that Landsat has been providing.

Elements in the determination of global change, for instance, in the world's forest stands, the extent and rate of deforestation, the extent and magnitude of desertification, the extent and changes in the world crop production are all important and it requires Landsat type of data in addition to, of course, mineral and oil exploration, evaluating geological hazards and identifying changes in snow and water availability for irrigation purposes.

As was stated earlier by EOSAT, we have worked with them over the past year in terms of putting together joint workshops to look at the kind of instruments discussed by Warren Nichols a few moments ago.

We also convened the panel to look at the future of an applications program over this past summer. We have now received that plan from the NASA Advisory Committee and you will hear about that on Wednesday.

Each of these efforts require to a different extent the availability of Landsat remotely sensed data to carry out investigations adequately. If such data are not available, many of the research efforts will be hampered and some will be delayed or seriously impaired.

While NASA by far is not the largest user of Landsat data, it is critical to many of our programs. It is very critical to the long term R&D programs of the United States.

Thank you very much.

[The prepared statement of Mr. Shelby Tilford follows:]

NASA
National Aeronautics and
Space Administration

Hold for Release Until
Presented by Witness

MARCH 31, 1987

Subcommittee on Natural Resources, Agriculture Research and Development

Committee on Science, Space and Technology

House of Representatives

Statement by:
Dr. Shelby G. Tilford
Director,
Earth Science and Applications Division
Office of Space Science and Applications

100th Congress

Statement of

Dr. Shelby G. Tilford
Director, Earth Science and Applications Division
Office of Space Science and Applications

National Aeronautics and Space Administration

before the

Subcommittee on Natural Resources, Agriculture
Research and Development

Committee on Science, Space and Technology

U. S. House of Representatives

Mr. Chairman and members of the Subcommittee: I am pleased to appear here today to testify before this Subcommittee on the Landsat program.

NASA has been one of the principal users of Landsat data since the inception of the program in the early 1970's. If Landsat type data beyond Landsat-5 were not available, our research programs in hydrology, biology, geology, forestry, oceanography, and other geosciences would be impacted. Landsat type data are a fundamental tool for research performed in these fields.

As you are also aware, NASA has been one of the originators, leading proponents and supporters of the proposed new "Global Change/International Geosphere-Biosphere Program " (IGBP) recently approved by the International Council of Scientific Unions (ICSU) in September, 1986. NASA and the National Science Foundation have supported the formation of a U.S. National Academy of Sciences/National Research Council "Global Change/IGBP Committee" which the Academy has just announced. Each of these new national and international programs will depend heavily on the availability of global data sets. One of the most important of these data sets we believe to be multispectral, high resolution digital land data such as that provided by the current Landsat-5 and the proposed Landsat-6 program. In addition, the NASA Advisory Council's Earth System Sciences Committee (ESSC) chaired by Dr. Francis Bretherton has, over the past three years, closely reviewed the requirements for measurements necessary to understand how the land, ocean, atmosphere and biosphere interact. One of the data sets which that Committee has identified for determining long term trends on how the surface is changing is the data from the Landsat Program. Landsat data have been available now for fifteen years and are an important element in the determination of global changes in the world's forest stands, the extent and rate of deforestation, the extent and magnitude of desertification, and the extent and changes in the world crop productions. These data are also used for mineral and oil exploration, evaluating geological hazards, and in identifying changes in snow and water availability for irrigation purposes.

NASA has followed the direction and intent of Public Law 98-365, the "Land Remote-Sensing Commercialization Act of 1984" to continue and to enhance programs of remote-sensing research and development. We have augmented our Land Processes Research and Analysis Program and we have proceeded with the development of an advanced Synthetic Aperature Radar (SAR) program. we have developed an Advanced Visible and Infrared Imaging Spectrometer (AVIRIS) for deployment on the NASA ER-2 high flying aircraft, initiated advanced studies and initial development of components for a high spectral/high spatial resolution instrument (SISEX/HIRIS) to be flown on the shuttle and subsequently on the Polar Platform of the Space Station, continued the technology development for advanced array detectors in the infrared and thermal regions of the spectrum, increased basic research at universities, and initiated an Interdisciplinary Research Program. We have also studied advanced sensors for ocean color observations. Through joint working groups with EOSAT, we have worked to define the potential value of space acquired multiband thermal remote sensing and ocean color observations in terrestrial research and commercial applications and have identified the scientific and technical requirements for conducting such observations from a Landsat satellite.

This past summer, we held a one week workshop convened by the NASA Space Applications Advisory Committee with representatives from industry, other government agencies, universities, and other representatives from the private sector to define a series of steps in the development of a Remote Sensing Applications/Commercialization Program. NASA has received the recommendations of that workshop and the Earth Science and Applications Division and the Office of Commercial Programs have developed a plan to issue an announcement for proposals later this summer.

Each of these efforts requires, to a different extent, the availability of Landsat remotely sensed data to carry out these investigations adequately. If such data were not available, many of our research efforts would be hampered and some would be delayed or impaired by the lack of such data. While NASA may not be the largest user of Landsat data in the current environment, these data are still critical to many of our programs.

Thank you.

Mr. SCHEUER. Thank you very much, Dr. Tilford. Mr. Michaud? I would ask all of you not to read your prepared testimony but just talk to us. You have been sitting here. You have heard 2 or 3 panels. You have heard a lot of very stimulating testimony. You have heard our concerns. Just talk to us.

Mr. MICHAUD. Thank you, Mr. Chairman.

Our concern is not that of a technical agency. Our concerns deal with leadership, the ability to influence events and the ability to engage in cooperation in science and technology with other nations.

If we were to lose the Landsat capability, let me just tick off some of the things that would concern us. First of all, we would become increasingly reliant potentially on foreign sources for skills and technologies. We would become increasingly reliant on foreign sources for data and the absence of our own system would reduce our leverage in seeking such data.

While we would hope we would have access to such data, the non-availability of an American system would enable other suppliers of data to use leverage on us to seek concessions in other areas. We would lose the good will, credibility and trust of foreign ground station operators. If we chose to re-enter this field, we would find the cost of re-constructing that good will, trust and cooperation potentially high.

We would, if we dropped out of this field, encourage others along the trends which we are concerned may already be occurring, which is to turn away from cooperation with America in space science and technology and to go autonomous or to seek other sources of cooperation.

In some circumstances, this might open up opportunities for the Soviet Union. I would note, Mr. Chairman, that the Soviets have launched a major space cooperation initiative offering launch services, time on their communications satellites, experiment time on Soviet space stations and the use of Soviet remote sensing satellites.

Finally, our withdrawal from this field would deprive the Agency for International Development of a tool which it has found useful in assisting developing countries and in encouraging them to work with us.

To sum up, Mr. Chairman, we believe that an active and influential U.S. presence in this field is in the national interest.

[The prepared statement of Mr. Michael A.G. Michaud follows:]

TESTIMONY OF MICHAEL A.G. MICHAUD ACTING DEPUTY ASSISTANT SECRETARY OF STATE FOR SCIENCE AND TECHNOLOGY AFFAIRS

Before the Subcommittee on Natural Resources, Agriculture Research and Environment and the Subcommittee on International Scientific Cooperation
Committee on Science, Space, and Technology
U.S. House of Representatives

March 31, 1987

Mr. Chairman, thank you for inviting us here today to testify on LANDSAT.

While the Department of State is not a technical agency, we take a strong interest in America's strength in science and technology, and in our ability to advance foreign policy interests through scientific and technological cooperation. The United States pioneered the practical use of many space technologies, strengthening our position of world leadership in science and technology.

Civilian remote sensing of the Earth from space is an excellent example. The United States pioneered the use of this technology. Through LANDSAT, we demonstrated our innovative and technical skills. We employed those skills not only for the betterment of the United States, but also of the world community. Our policy of making LANDSAT data available to the world's scientific, research, and commercial interests on an open, equal, non-discriminatory basis dramatized our commitment to an open world, and established a model for others to folow. This model made observation of the Earth from space more acceptable to other nations, assisting our national security and arms control interests. An extensive network of international cooperation has grown up in this area, with exchanges of data and regular meetings of interested managers and experts. Our colleagues in the Agency for International Development have found LANDSAT to be a useful tool in assisting developing nations and encouraging those nations to work with us. In addition, space-based Earth observation systems have stimulated technology development and the creation of an American "value-added" industry which contributes to American economic and commercial strength.

If the LANDSAT program were discontinued, our technical capability in this field could decline, and we could find ourselves increasingly reliant on foreign sources for skills, technologies, and data. France and Japan have indicated that they will observe a policy of open, non-discriminatory distribution of data. We hope that this policy will be observed by future foreign operators of civilian remote sensing satellites.

If the LANDSAT program were terminated, foreign ground receiving station operators would have to find other satellites to tap. If LANDSAT were not continued, these countries would have to make use of the French SPOT system, which others already may be able to incorporate into their data reception facilities. Foreign ground station operators who for years have received LANDSAT data and worked with U.S. program and technical managers would be likely to orient their technology, their distribution networks, and their commercial activities in this field even more toward other nations.

Thank you, Mr. Chairman.

Mr. SCHEUER. Thank you very much, Mr. Michaud. Mr. Frederick?

Mr. FREDERICK. Mr. Chairman, from the Department of the Interior point of view, our interest in Landsat is both as an user, as mentioned several times this morning, and as an active participant in the program since its inception. In the Geological Survey, we operate the EROS Data Center which handles the data and does research in the application of that data. Our interest is fairly broad.

Specifically from the user point of view of the Department of the Interior, almost every bureau in that Department uses Landsat information in one way or another from a scientific point of view, all the way to the management of lands in the Bureau of Land Management, the Bureau of Indian Affairs to snow, ice cover and concerns about floods and reservoir management.

Those programs are active and generally are operational with the Landsat data along with other information that we have that is very useful in running those programs. As future applications are concerned, we see that continuing, both in terms of making more effective use for the present applications and looking at new applications which have been discussed here today, including both national and global kinds of concerns that are available.

From our point of view, we would lose a very valuable data source, one that has been discussed by my colleagues here in terms of covering on a synoptic basis fairly large portions of the earth's surface and in the digital form that we can readily use.

I guess the question of what happens if we don't have a Landsat, we are committed enough to remote sensing applications that we will have to find some other way. Aircraft sensors or other satellites from the Japanese or the French or other sources, or perhaps from that 15 year old archive base that is available from Landsat.

With that, I will stop.

[The prepared statement of Mr. Doyle Frederick follows:]

Statement of Mr. Doyle G. Frederick, Associate Director
U.S. Geological Survey, Department of the Interior
before the
Natural Resources, Agriculture Research and Environment Subcommittee
and the
International Scientific Cooperation Subcommittee
of the Science and Technology Committee
of the House of Representatives

March 31, 1987

Mr. Chairman, I am pleased to participate in this joint hearing to discuss the Department of the Interior's involvement in the Nation's Landsat program. We have entered a new era with remote sensing technology and Interior has been an active participant in the Landsat program from its inception. During this last decade, our scientists have found Landsat data to be very useful in combination with other forms of geologic, cartographic, and geophysical data, to support geologic analyses, hydrologic assessments, resource management, image mapping, and applications research.

The U.S. Geological Survey is not only a user of Landsat data, but also cooperates with NOAA and EOSAT in the final data processing, product generation, and distribution of Landsat data. The Survey's EROS Data Center, located in Sioux Falls, South Dakota, was established in the early 1970's with responsibilities to process, archive, and distribute Landsat data, at first in cooperation with NASA, and continuing today in support of NOAA and the Landsat commercial operator, the EOSAT Company.

At this time, I would like to respond to the three questions posed by the subcommittees:

1. WHAT ARE THE CURRENT DEPARTMENT OF THE INTERIOR USES OF LANDSAT?

Interior is currently making routine, operational use of Landsat data in support of several programs. Specific examples of Interior use include:

- Inventorying Alaska Federal lands and mapping of vegetation and land cover (BLM, F&WS, NPS, GS);
- Identifying and analyzing potentially mineralized zones and rock alteration areas (GS);
- Mapping and identifying geologic structures for hazard assessment (GS);
- Inventorying surface water and monitoring water quality (GS, F&WS, BOR);
- Monitoring sea ice related to marine mammal migration, oceanographic studies, and engineering activities of the offshore oil industry (MMS);
- Mapping irrigated lands to determine water use (BOR, GS);

- Carrying out regional environmental surveys to prepare environmental impact statements (GS, BOR, BLM, F&WS);
- Preparing image maps of selected areas of the U.S., unmapped or poorly mapped regions of the Antarctic, and other regions in support of national and international cooperative efforts (GS).

Each Interior Bureau is involved in the analysis and use of Landsat data. These activities occur at five regional and many field locations throughout the country.

2. WHAT ARE THE FUTURE POTENTIAL USES OF LANDSAT DATA BOTH BY THE DEPARTMENT AND BY NATURAL RESOURCE INTERESTS?

Listed below are examples of future applications of Landsat data within our Department that are expected to achieve operational status with further refinements in data characteristics or analysis procedures:

- Agricultural crop classification for determination of irrigation water use;
- Monitoring agricultural trespass on Federal lands;

- Monitoring snow cover accumulation and melt in watersheds and hydroelectric catchments as input to predictive hydrologic models and runoff calculations;
- Mapping rangeland condition and monitoring changes caused by land conversion and drought conditions;
- Geohydrologic analysis and ground water exploration methodologies;
- Predicting hazard zones in underground coal mines;
- Monitoring of forest defoliation and other types of vegetation stress;
- Assessing and monitoring physical water quality and turbidity;
- Inspecting small-scale topographic maps for map revision; and
- Shallow seas mapping in the Trust Territories.

3. WHAT DOES THE U.S. LOSE WITHOUT A LANDSAT SYSTEM?

The Department of the Interior and the Nation would lose a data source that provides a synoptic view of the Earth's surface, is acquired on a frequent and repetitive cycle, and is available in digital (computer-compatible) format. Because of our mission for gathering, disseminating, and using information about the Nation's land and water resources, we will continue to be an active investigator and user of remotely sensed data from current and future satellite remote sensing systems. If the Landsat program is terminated, the Interior Department and the U.S. Geological Survey would, to the extent possible, continue to meet responsibilities by relying upon aircraft and two sources of civil satellite data--the historic Landsat data collected over the last 15 years, which is archived at the U.S. Geological Survey's EROS Data Center, and new acquisitions purchased from foreign system operators. For new data sources, Interior and the U.S. Geological Survey would purchase data from the French who recently launched a civilian Earth observation satellite. In the future, other nations may also have such capabilities.

Examples of important capabilities of Landsat data that would be lost include:

- Efficient and cost-effective analysis of vegetation and resource characteristics of large frontier areas, such as Alaska;

- Confidentiality of data selection for mineral and hydrocarbon exploration; and

- Continuity of a 15-year data set; long-term data will be essential to monitor and predict change on a global scale.

The Federal Government has already made over a $1 billion investment in Landsat. The Administration believes that the private sector, which reaps the primary benefit of Landsat, should assume a greater role in financing the program. While the Department of the Interior would continue to purchase Landsat data for our own use, this should not imply we believe that additional Federal Government investment is needed.

Mr. Chairman, that concludes my formal statement. I would be pleased to answer any questions the members might have on Interior's use of this important tool.

Mr. SCHEUER. Thank you, Mr. Frederick. Mr. Donald.

Mr. DONALD. Mr. Chairman, the Department of Agriculture, as you know, is also a user. Let me mention that remote sensing is one of the sources used by the Department. There are other sources which we use in our research programs, in our operational programs, Mr. Chairman, as you well know. We use Landsat. We use airborne sensors. We also use ground based sensors.

The Department's use, Mr. Chairman, of the Landsat data or the remote sensing data is tied to its costs, its reliability and its availability. Let me mention the major use within the Department. The major use of Landsat information is the development of global crop production estimates, as a major user, by the Foreign Agriculture Service within the Department. Also that information is used to monitor crop conditions, crop developments around the world so our Secretary doesn't get surprised.

Now, the information, Mr. Chairman, is most useful for those countries where we cannot travel, where travel is restricted or not very easy. I might mention the Soviet Union in particular is one application where this information is in fact used by the Department.

For example, the information from Landsat is very useful along with information from other sources in making assessments say of Soviet grain production.

I won't really get into the domestic side. There are also some applications there in terms of improvements in acreage estimates and monitoring forest lands and soils and so forth.

In the absence of Landsat data, as you have just heard here, it would be a loss of an important data source for the Department. We would look at some of the other satellites and sources that have been mentioned here, meteorological satellites, the foreign satellites. There are some advantages and disadvantages there, as this group has already heard.

Mr. Chairman, let me just mention one final point. The Department in making decisions about whether we use Landsat or other type of information will of course be guided by budgetary considerations, Administration guidelines or whatever, and costs in relationship to improvement in the analyses and forecasting.

That concludes my remarks, Mr. Chairman.

[The prepared statement of Mr. James Donald follows:]

Statement by
James R. Donald
Chairperson, World Agricultural Outlook Board
U.S. Department of Agriculture
before the
House Committee in Science, Space and Technology
Subcommittees on Natural Resources, Agricultural Research,
and Environment and International Scientific Cooperation
March 31, 1987

Mr. Chairman and members of the Subcommittees, I appreciate the opportunity to serve as a panel member to discuss use of Landsat data by the Department of Agriculture. I would like to submit a statement for the record. In this statement I cover the possible consequences if data from the Landsat system are no longer available.

Remote sensing is one of the data sources used by the USDA in decisionmaking. We use remotely sensed data acquired from airborne and space-based sensors, such as those carried by Landsat, and ground-based sensors in research and operational programs. We feel that data from satellites can be used effectively in existing or planned USDA information systems and that such data use will improve the objectivity, reliability, timeliness, and adequacy of those information systems. Due to budgetary constraints, USDA reduced purchases of Landsat data in the last three years.

To adapt satellite data, including Landsat data, to its specific information needs, USDA has been engaged in an extensive and continuing program of applications research and development. We feel that we are making progress and that data from space-based sensors have potential as a unique information source for agriculture.

With specific regard to applications of Landsat data, the principal user, in terms of quantity, is the Foreign Crop Condition Assessment Division of USDA's Foreign Agricultural Service. The primary function of this division is to provide USDA commodity analysts in with reliable and timely information about the conditions and expected production of foreign crops of economic importance to the United States. This information is used by USDA in developing worldwide agricultural supply and demand estimates for public distribution.

The FAS division routinely receives, processes, and analyzes Landsat digital data from the Landsat system and other systems to monitor high priority foreign crop producing areas. Landsat high density data tapes are processed and analyzed in a well-equipped remote sensing center located in the USDA complex. Remote sensing techniques have been very helpful in identifying and delineating foreign crop areas where major changes are taking place. The capability provided by Landsat for a "closer look" has proved to be very important for those areas where ground travel is restricted or denied. Remotely-sensed data, such as that provided by Landsat, combined with data from other sources, materially aided USDA's estimation process for this important country.

On the domestic side, the National Agricultural Statistics Service is a major user of Landsat data in an operational context. At the present time, NASS uses Landsat data to improve the accuracy of crop acreage estimates for winter wheat, corn, soybeans, rice, and cotton in the states of Kansas, Oklahoma, Colorado, Missouri, Iowa, Arkansas, Illinois, and Indiana. In addition, NASS is also continuing pilot-level research on the use of Thematic Mapper data from the Landsat system for improved sampling frames and crop acreage estimates. The Agricultural Stabilization and Conservation Service is engaged in a cooperative program with FAS to develop the use of space-based data to monitor special problems related to U.S. crop conditions, for example, flooding.

Both the Forest Service and the Soil Conservation Service are engaged in developing uses for data from space-based systems. Using Landsat data for information, the Forest Service has created Geographic Information Systems (GIS) for several national forests. Landsat data, in digital form, are integrated with other digitized data bases -- terrain, vegetation types, transportation net, cultural features. The resulting systems improve forest management, and enable rapid analysis of timber inventories, forest fire hazards, and wildlife habitats.

Although relatively small in terms of its use of Landsat data, the Remote Sensing Research Laboratory of the Agricultural Research Service (ARS) provides significant research support to other agencies of USDA. Current projects include comparative studies of remotely-sensed data from the Landsat and other space systems.

So far as future uses of Landat are concerned, data could be used in combination with other data sources, including data from other satellite sensors. This would improve both accuracy and efficiency for land cover estimation and monitoring and would lead to quantitative assessment of yield or crop production potential. The end result at the national level could be timelier and more accurate crop estimates. At the local level, and assuming that problems related to frequency and timeliness of coverage can be resolved, it may be possible for local operators -- farmers, ranchers -- to incorporate information from the Landsat system in day-to-day operational decisions with advisories provided (in many instances) by consulting firms which analyze data for smaller areas.

The fact that Landsat data, from both the Multispectral Scanner and the Thematic Mapper, are in digital form is the system's greatest asset. Landsat data can easily and effectively be analyzed with computers. When linked to other digital data bases, Landsat data become an integral component of Geographic Information Systems, which could materially aid both crop monitoring as well as renewable resource management.

Changing information needs as well as changing technology make any assessment of the loss of the Landsat system a difficult task. The USDA has investment in research, equipment, data analysis, and personnel, not to mention the cost of Landsat data as such. It is true that the existing structure could be adapted to other space-based data systems. However, it should be noted that a significant shift to satellite data sources other than Landsat would require expenditures for new equipment and computer software, and additional timed to re-establish the FCCAD analysis system.

That the loss of Landsat data would adversely impact our efforts to assess agricultural conditions in those countries where travel is restricted or denied, or where existing agricultural statistical systems are poor or non-existent, is obvious. For example, the USSR is a major determinant in world trade in such important commodities as grain, cotton, and oilseeds. Given present limited access and paucity of statistics, remotely-sensed data could become more important.

Although data from other space-based systems are available and could be used as a limited substitute for Landsat data, there are technical and physical limitations as well as budgetary and institutional concerns. For example, data from the U.S. polar-orbiting weather satellites can be used for qualitative assessments. Low resolution weather satellite imagery over many other countries, including Africa, India, Australia, Mexico, and China, is received and helps to assess general conditions. However, the coarse spatial resolution of the weather satellite data, about 1 km, does not permit the precision of measurement and analysis possible with Landsat data.

Data from the French SPOT satellite have finer spatial resolution than the Landsat data, but also, are not a direct substitute and cost much more for the same area of coverage. Timeliness is another factor. As yet, SPOT data from foreign areas are not delivered in time for current assessments.

At present, there is no other satellite system which can provide the exact kind of data which Foreign Crop Condition Assessment Division of the Foreign Agricultural Service now depends on Landsat to provide. It is important to realize that the analytical procedures used today by FCCAD have been developed over a number of years. Remotely-sensed data over a span of more than a decade are available for comparison with current crop conditions. A change from Landsat data would require additional research, for example, recomputation of vegetative index numbers, even if the new data could be sufficiently calibrated.

At the present time, the French operate the SPOT system and have provided assurances that the data will be distributed in an open and non-discriminatory manner.

On the domestic side, the capability for "quality control" over ground-based statistical data will diminish greatly. Data from satellite systems, such as Landsat, offer a parallel check, a chance to compare data from traditional land-based survey systems with an independent source.

The Government has already made over a $1-billion investment in Landsat. The Administration believes that the private sector, which reaps the primary benefits at Landsat, should assume a greater role in financing the program. The USDA would continue to purchase Landsat data for its own use. However, this should not imply that additional Government investment is needed.

Mr. SCHEUER. Thank you. Co-Chairman Ralph Hall.

Mr. HALL. Thank you, Mr. Chairman. I will just ask a very logical question about our withdrawal from Landsat and whether or not that would have any effect on the willingness of other nations to enter into joint scientific ventures with us. I ask that because this overall Committee on Science, Space and Technology has just formed a new Committee of which Chairman Scheuer is the senior Democratic member, senior member of the Committee, I suppose. We will be looking for international scientific sources of cooperation.

In this that we are discussing here today, if we withdraw from Landsat, fail to fund it, what is the likelihood that we would be able to enter into joint ventures with other nations? I guess the logical question, the second one, would it make other nations more likely or less likely to join into joint scientific ventures with the U.S.S.R., which is the step that we are trying to preclude? They would certainly run into their arms, wouldn't they?

The gentleman from the State Department I think could answer that better than I can.

Mr. MICHAUD. Yes, Mr. Hall. I guess the bottom line from our point of view is if we are going to engage in cooperation with other nations in the use of space sciences, that we have to bring something to the table. If we don't have an earth remote sensing system, our leverage in cooperating with other nations is drastically reduced. Their interest in us as a cooperative partner may be comparably reduced.

Mr. HALL. In the Landsat Act of 1984, the U.S. committed itself to an open skies thrust. Do France and Japan that we have talked about going into some kind of joint or seeking their technology, do they adhere to that? Do you know?

Mr. MICHAUD. Mr. Hall, both countries have indicated they intend to observe open data distribution policies but let me note that we led the way in establishing that as an international principle and that if we withdraw from this field, once again our leverage in maintaining that principle internationally has been reduced.

Mr. HALL. If there are no U.S. systems, they would be more reluctant logically.

Mr. MICHAUD. Well, they could make a judgment that it is less necessary.

Mr. HALL. We would be at their mercy.

Mr. MICHAUD. Yes.

Mr. HALL. That's the long and short of it. To what extent could you substitute other data sources for Landsat, substitutes such as SPOT or weather satellites or something like that?

Mr. MICHAUD. Mr. Hall, I think I should defer to the technical agencies to answer that question.

Mr. TILFORD. I don't believe there is any substitute for the kind of information that is available from Landsat as discussed by the Under Secretary of Defense. There is no equivalent right now. There are certain aspects of both the SPOT data and the Japanese data that are useful. However, neither substitute for the kind of spectral information that is currently available from Landsat.

Mr. HALL. Do you think your agencies would be willing to kick in a little more money to preserve Landsat or is it your position that Commerce ought to pay it all?

Mr. TILFORD. As discussed earlier by EOSAT, sir, we have had negotiations going on with EOSAT for the past year in order to see if we can work out some cooperative methods in which we can jointly do some things which we hope would preserve the vitality of EOSAT. I don't think it is enough from what we have been trying to do to preserve EOSAT, although we are looking towards the future and we see EOSAT and potentially the Landsat platforms are a way of providing additional information in the future and we have supported them in that effort.

Mr. HALL. You all have submitted written statements, haven't you, that we can read more carefully. Mr. Chairman, I certainly would recommend they be made a part of the record. I thank you. I yield back my time.

Mr. SCHEUER. Thank you, Ralph.

In a recent newspaper article of February 23d, Joseph Wright, our opening witness today, is quoted in the—Deputy Director of OMB—is quoted in the Washington Post as saying the Landsat program largely duplicates existing services already provided by weather and military satellites with the aside that these services benefit users such as oil companies more than they do the public at large. Much of the information we can obtain through other sources, with the clear implication that it wouldn't be all that great a tragedy if Landsat were to disappear.

Any response?

Mr. TILFORD. I respectfully disagree with that assessment.

Mr. HALL. I would especially agree with your disagreement.

Mr. SCHEUER. Mr. Michaud?

Mr. MICHAUD. From our point of view, Mr. Chairman, we think it's important to maintain a civilian earth observation system as distinct from operated by the military.

Mr. FREDERICK. From an applications point of view, we think it would be a significant loss to lose the Landsat capability, the repetitive coverage, the large areas and some of the spectral information that comes from that source are important. If it is not there, it would be a loss.

Mr. DONALD. Mr. Chairman, the Department of Agriculture is very interested in having some continuity of data there. We have quite an investment in that system, of course.

Mr. SCHEUER. Is Joseph Wright right when he commented in the Washington Post that much if not most of this information is available elsewhere?

Mr. TILFORD. That was the comment I was disagreement with. I don't believe that information is available from any other system.

Mr. HALL. I understood——

Mr. SCHEUER. How—go ahead, Ralph.

Mr. HALL. No, I was just telling the gentleman I understood him.

Mr. SCHEUER. Has the feeling of your agencies been conveyed in clear and unmistakable terms to OMB?

Mr. MICHAUD. Mr. Chairman, may I speak to this?

Mr. SCHEUER. Please do.

Mr. MICHAUD. We have communicated formally to the NSC, not OMB, our concern about the future of U.S. civil remote sensing.

Mr. SCHEUER. Well, can I ask you to communicate your feelings to OMB? They seem to be sitting in the cat/bird seat at this point in time and they seem to be the locus of the problem.

Mr. MICHAUD. Certainly, Mr. Chairman.

Mr. SCHEUER. Would you do that? We would welcome any of your four agencies in addition to the State Department communicating directly to OMB, Mr. Wright, the fact that this flow of data is not fungible and if it doesn't come from Landsat, it is not going to automatically flow from other places and other facilities.

Mr. Michaud, I take it you are saying that if the flow of information from Landsat alters, and we are pretty much out of it in terms of producing that flow of information ourselves, that if we need access to the French and the Japanese, it's problematical as to whether they will give it to us in the first place and if they do, it may be at a very large cost in other matters that we would be negotiating.

Is that a fair summary?

Mr. MICHAUD. Mr. Chairman, it's hard to predict but that is potentially true. It is of course speculative. At the moment we have quite good relations with both the French and the Japanese. We also have leverage and in the absence of Landsat, we would not have the leverage.

Mr. SCHEUER. That would give them leverage to use in all kinds of other negotiations with us.

Mr. MICHAUD. Potentially, that's correct.

Mr. SCHEUER. For example, we seem to have a clear disagreement with the Japanese on the terms of trade, it has taken a very harsh form just in the last week. Our Administration has been forced to take action against the Japanese in the field of computer chips and in fact, in a number of commodities, that was very painful for us. We didn't want to do this. We felt driven to do that.

Is it beyond the realm of possibility that if we were relying on the Japanese for earth sat data, we might feel much less free to take what we consider to be appropriate and fair and reasonable and equitable steps to achieve a fair playing field, a level playing field in terms of trade?

Mr. MICHAUD. Mr. Chairman, my sense of things is that the trade issue is so overwhelmingly dominant in U.S./Japan relations, that it would far outweigh any gain in the earth remote sensing area or any exchange of data in that field, but there may be other areas of cooperation with Japan where it could be affected.

Mr. SCHEUER. Let me just ask you one more question. A number of people have suggested that one way to remove Landsat from the vicissitudes, the pulling and ambivalence of the budget, the annual budget process, is to ensure development of cutting edge technology through a global consortium for development, both for development and use of a remote sensing system, more or less based on the philosophy and approach of INTELSAT.

Does such an approach seem feasible to you?

Mr. MICHAUD. Mr. Chairman, we have not studied this proposal but we know it has been made privately. From our point of view, I think we would reiterate our concern that if you are going to follow the INTELSAT model, you have to have a strong COMSAT as a domestic entity.

Mr. SCHEUER. We have to have a strong national presence.

Mr. MICHAUD. That's correct.

Mr. SCHEUER. In satellite sensing.

Mr. MICHAUD. If you dropped out of this field, you wouldn't have the kind of leverage you would need in that kind of an international organization.

Mr. SCHEUER. You wouldn't be a major player.

Mr. MICHAUD. That's correct.

Mr. SCHEUER. How do you feel about the suggestion that we made a few times this morning to elicit opinion that we might possibly do some kind of joint venture with the French or the Japanese or both?

Mr. MICHAUD. Mr. Chairman, it's difficult to call this one in advance because we are talking about a commercial entity in the case of the United States and we can't direct them to enter a joint venture or not enter a joint venture, but I think we would be concerned about maintaining some degree of national control over our earth remote sensing system. If we could preserve that kind of control and access to the system about which the Department of Defense spoke earlier, then perhaps it is something we could look at.

Mr. SCHEUER. Let's assume we could define a way that we could keep some control through the U.S. presence out there. Are you telling me we have no way to effectuate a national policy that would involve sharing of technology in a joint venture approach by which let's say the three of these nations, if they are interested, the French and the Japanese, would contribute to the multi-billion dollar capital costs of getting the technology up there and operating it over a period of years?

Mr. MICHAUD. No, Mr. Chairman. I wouldn't make that flat a statement. I'm simply saying we haven't looked at the issue and it would involve our relationship with the private corporation under the legislation passed by Congress. I would prefer that we study the issue before we offer you an opinion on it.

Mr. TILFORD. Mr. Chairman, within NASA we have been working very closely with both ESA and the Japanese in looking at how we might utilize especially the polar platforms of the space station in the future. We have had a series of negotiations going on for the past year and a half on putting joint instruments from different sources on different platforms provided by different countries. We think there is a mechanism for doing this. It's very complex. I think the technology transfer issue is the biggest one that we are going to have to deal with.

However, there has been a willingness by both the European Space Agency and the Japanese space elements to work cooperatively toward this kind of system in the mid-1990's. The additional point Mike made——

Mr. SCHEUER. To work?

Mr. TILFORD. To work toward a cooperatively earth observing system which includes the atmosphere, the ocean and the land.

Mr. SCHEUER. A joint venture approach?

Mr. TILFORD. That's correct. We have investigated this. We have gone through a whole series of details and negotiations on who provides what kind of instrumentation and how the data might be shared. In addition, of course, we have been working with ESA ensuring the ERS-1 data and we are also negotiating with the Japanese to do the same kind of thing. However, the points Mike made with respect to the commercial end, we have not yet worked out those details. However, by the mid-1990's, I think these kind of arrangements can be possible.

Mr. SCHEUER. If they could be possible in the mid-1990's, should we start talking about them now so nations don't make an irrevocable decision to go it on their own and therefore foreclosed by decisions they would make now to the possibility of entering into joint venture arrangements?

Mr. TILFORD. I would say we have started those negotiations already.

Mr. SCHEUER. Very, very good. My colleague.

Mr. HALL. Only just a rumor that I've heard and unsubstantiated. Has OMB ever discouraged any of your agencies from buying LANDSAT data?

Mr. TILFORD. No, sir.

Mr. MICHAUD. No, sir.

Mr. HALL. Mr. Chairman, I don't have anything else. Thank you.

Mr. SCHEUER. Dr. Tilford, I think we would like a private briefing on exactly what has happened in terms of informal, preliminary negotiations on a possible joint venture approach.

Mr. TILFORD. We would be very glad to present that to you.

Mr. SCHEUER. We will be in touch with you and we will set up a briefing.

This has been an excellent——

Mr. HALL. Array of talent.

Mr. SCHEUER. Array of talent. [Laughter.]

We have been very stimulated. The sun has not only passed over the yardarm, but it is a few minutes after 2. We thank you very much for your patience and for your very forthright and very much to the point testimony.

The Committee will adjourn now until our second hearing Thursday, that will be chaired by Co-Chairman Ralph Hall and will deal with the whole spectrum of private users of space data, the universities, the business groups, the media and it promises to be a very interesting session chaired by my Co-Chair, Ralph Hall.

The meeting is adjourned until Thursday morning.

[Whereupon, at 2:05 p.m., the Subcommittee recessed, to reconvene at the call of the Chair.]

THE FUTURE OF THE LANDSAT SYSTEM

THURSDAY, APRIL 2, 1987

House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Natural Resources, Agriculture Research and Environment and the Subcommittee on International Scientific Cooperation

Washington, DC.

The subcommittee met, pursuant to notice, at 9:39 a.m., in room 2325, Rayburn House Office Building, Hon. Ralph M. Hall, (chairman of the Subcommittee on International Scientific Cooperation) presiding.

Mr. Hall. Okay, we will get underway with the joint hearings on the Subcommittee on International Scientific Cooperation and the Subcommittee on Natural Resources, Agriculture Research and Environment will come to order. We're co-chairing this with Congressman Scheuer who will be here a little bit later.

Today's hearing is the second of two days of hearings on the future of the Landsat program. At our first meeting on Tuesday we heard testimony from the private Landsat contractor, EOSAT, and from a wide range of federal agency witnesses, including the Office of Management and Budget.

At that hearing there was a very clear and strong consensus among the members of the committee on a number of points, some minor differences and variances. But first, the the United States pioneered remote sensing technology, and after an expenditure of about $1.5 billion, it seems we may be about to give it up to France and Japan.

And second, that Landsat has important applications for the national security or energy security and our national competitiveness. And third, if the U.S. hopes to remain a play in the remote sensing arena, a minimum of two satellites, Landsat 6 and 7 need to be furnished.

Today we'll hear from a wide range of private sector users of the Landsat system, including the oil and gas industry, ocean industry, state and local government, the news media, the value-added industry, and environmental and research groups. And we'll also hear from a representative of the French SPOT system, the major international competitor of Landsat.

We intend today to continuing building a full and complete record of the cost and benefits of continuing the system. At the conclusion of these hearings, the committee intends to issue a report on its findings and to share this report with our colleagues in both bodies who will make the ultimate decision on the fate of the Landsat system within the next few months.

And with that, I would yield to any of the members of the committee who would like to make an opening statement or any remarks.

[The prepared opening statements of Mr. Hall and Mr. Scheuer follow:]

STATEMENT OF THE HONORABLE RALPH HALL
HEARING ON STATUS OF THE LANDSAT PROGRAM
APRIL 2, 1987

THIS JOINT HEARING OF THE SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION AND THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT WILL COME TO ORDER.

TODAY'S HEARING IS THE SECOND OF TWO DAYS OF HEARINGS ON THE FUTURE OF THE LANDSAT PROGRAM. AT OUR FIRST HEARING, ON TUESDAY, WE HEARD TESTIMONY FROM THE PRIVATE LANDSAT CONTRACTOR (EOSAT) AND FROM A WIDE RANGE OF FEDERAL AGENCY WITNESSES, INCLUDING THE OFFICE OF MANAGEMENT AND BUDGET.

AT THAT HEARING THERE WAS A CLEAR AND STRONG CONSENSUS AMONG THE MEMBERS OF THE COMMITTEE ON A NUMBER OF POINTS:

> FIRST, THAT THE U.S. PIONEERED REMOTE-SENSING TECHNOLOGY AND, AFTER AN EXPENDITURE OF $1.5 BILLION, IS ABOUT TO GIVE IT UP TO FRANCE AND JAPAN;
>
> SECOND, THAT LANDSAT HAS IMPORTANT APPLICATIONS FOR OUR NATIONAL SECURITY, OUR ENERGY SECURITY, AND OUR NATIONAL COMPETITIVENESS; AND

THIRD, IF THE U.S. HOPES TO REMAIN A PLAYER IN THE REMOTE-SENSING ARENA, A MINIMUM OF TWO SATELLITES -- LANDSATS 6 AND 7 -- NEED TO BE FUNDED.

TODAY WE WILL HEAR FROM A WIDE RANGE OF PRIVATE-SECTOR USERS OF THE LANDSAT SYSTEM, INCLUDING: THE OIL AND GAS INDUSTRY; OCEAN INDUSTRY; STATE AND LOCAL GOVERNMENT; THE NEWS MEDIA; THE VALUE-ADDED INDUSTRY; AND ENVIRONMENTAL AND RESEARCH GROUPS. WE WILL ALSO HEAR FROM A REPRESENTATIVE OF THE FRENCH SPOT SYSTEM -- THE MAJOR INTERNATIONAL COMPETITOR OF LANDSAT.

WE INTEND TODAY TO CONTINUE BUILDING A FULL AND COMPLETE RECORD ON THE COSTS AND BENEFITS OF CONTINUING THE LANDSAT SYSTEM. AT THE CONCLUSION OF THESE HEARINGS, THE COMMITTEE INTENDS TO ISSUE A REPORT ON ITS FINDINGS AND TO SHARE THIS REPORT WITH OUR COLLEAGUES IN BOTH BODIES, WHO WILL MAKE THE ULTIMATE DECISION ON THE FATE OF THE LANDSAT SYSTEM WITHIN THE NEXT FEW MONTHS.

[... TURN TO OTHER MEMBERS FOR OPENING STATEMENTS]

OPENING STATEMENT

JAMES H. SCHEUER

FUTURE OF THE LANDSAT SYSTEM

APRIL 2, 1987

AS WE PROCEED WITH OUR SECOND DAY OF HEARINGS, I AM STRUCK BY THE EXTRAORDINARY LACK OF COMMITMENT THAT THE ADMINISTRATION HAS SHOWN TO THE LANDSAT PROGRAM. FROM THE VERY BEGINNING OF THIS EFFORT TO COMMERCIALIZE LANDSAT THE OMB HAS HAMSTRUNG AMERICAN INDUSTRY.

AFTER REVIEWING OUR FIRST DAY OF HEARINGS, ONE CAN ONLY CONCLUDE THAT IF THE AMERICAN SPACE INDUSTRY EVER ESTABLISHES A COMMERCIAL PRESENCE IN REMOTE SENSING, IT WILL BE IN SPITE OF, RATHER THAN BECAUSE OF, THIS ADMINISTRATION'S ASSISTANCE. THE ENTIRE DECISION MAKING PROCESS HAS BEEN MARKED BY POOR PLANNING, MISMANAGEMENT, DELAY AND INDECISION. DECISIONS HAVE BEEN REACHED, REVISED, AND REVERSED AGAIN WITHOUT THE SLIGHTEST ANALYSIS OF WHAT IS REALLY NEEDED TO COMPETE INTERNATIONALLY IN THIS FIELD.

THE COMMERCIALIZATION OF LAND REMOTE SENSING SHOULD HAVE BEEN AN

PROTOTYPE FOR COMMERCIALIZATION OF A WIDE RANGE OF SPACE SERVICES AND INDUSTRIES. INSTEAD, THE ENTIRE PROCESS HAS BEEN A DEMONSTRATION OF HOW WE CAN ONCE AGAIN ABANDON OUR TECHNOLOGICAL AND COMPETITIVE LEADERSHIP. IN TODAY'S HEARING WE WILL HEAR FROM PRIVATE SECTOR WITNESSES THAT WILL ADDRESS WHAT THIS COUNTRY WILL LOSE IF LANDSAT IS TERMINATED AND WHAT THE FUTURE WILL HOLD IF THIS REMOTE-SENSING TECHNOLOGY IS ALLOWED TO DEVELOP.

THANK YOU MR. CHAIRMAN.

Mr. McCurdy. Mr. Chairman.

Mr. Hall. Yes, the Congressman from Oklahoma.

Mr. McCurdy. If the gentlelady from Rhode Island is not going to go first——

Miss Schneider. No, thank you.

Mr. McCurdy. Since we're all classmates, maybe I can proceed. I'd just like to indicate to the subcommittee and add my welcome to Dr. Henderson who is a recently acquired constituent of mine in his recent move to Norman, Oklahoma. Dr. Henderson is as knowledgeable a person, I think there is, on Landsat and remote sensing in general. And certainly, I think will be providing a lot of very helpful and useful information to the subcommittees on the applications of remote sensing and Landsat.

And I'd hope he'd also indicate why he made his move to Norman, hopefully in anticipation that there be a ground station there and anticipation that this is where the action would be in this area. And we certainly hope that that will come to light or into fruition in the next few years.

But I appreciate the chairman's willingness to hold the hearings, as with Mr. Scheuer, and certainly appreciate the bipartisan support on this issue. And I yield back my time.

Mr. Hall. Miss Schneider?

Miss Schneider. I have no comment, thank you.

Mr. Hall. All right, thank you. All right, we might also say that Mr. Henderson is accompanied by Cole McClure of the Bechtel Corporation, and I think our friend Harry Stewart of Sun Exploration of Dallas.

And I would ask that you all, if you can, keep your presentation initial to five to seven minutes. We have your written testimony here and it will made a part of the record. And at this time the chair recognizes Fred Henderson, president of GEOSAT.

STATEMENTS OF DR. FREDERICK B. HENDERSON, PRESIDENT, GEOSAT COMMITTEE, NORMAN, OK, ACCOMPANIED BY HARRY STEWART, SUN EXPLORATION CORP., DALLAS, TX; SAMUEL W. McCANDLESS, JR., PRESIDENT, USER SYSTEM, INC., ANNANDALE, VA, REPRESENTING THE NATIONAL OCEAN INDUSTRIES ASSOCIATION; AND DR. THOMAS M. LILLESAND, UNIVERSITY OF WISCONSIN, MADISON, WI, REPRESENTING THE AMERICAN SOCIETY OF PHOTOGRAMMETRY AND REMOTE SENSING

Mr. Henderson. Thank you, Mr. Chairman and members of the subcommittees. It's a pleasure to be here to appear before you today. You're also early in your schedule on the day, based on Tuesday's experience. I'd also like to express my appreciation to Mr. McCurdy for his warm welcome.

In any case, our testimony here on behalf of the GEOSAT committee is fundamentally on the issue of completing the government payment for the continuing operating expenses for Landsat 4 and 5, and the building of Landsat 6 and 7 as was originally intended by the 1985 contract between the Department of Commerce and the EOSAT Corporation as a part of the United States government to commercialize Landsat.

More importantly, however, we wish to emphasize our long term support for the United States government and industry to commit to long term continuity of civil, land, and ocean remote sensing satellite programs in the United States. And for continuity—for international compliance with and continuity of the U.S. principles for open skies and non-discriminatory access to data.

Mr. Harry Stewart of Sun is Vice Chairman of the GEOSAT Committee and he is here with me to help answer questions. Mr. McClure expresses his regrets for not being able to be here today.

I was asked to make a few comments about the new technologies that we see in terms of the French and Japanese systems, et cetera. But first I'd like to make a few general comments with respect to the commercialization. Many of our concerns were expressed on Tuesday, and I'm sure will be expressed today.

We believe that the commercialization process is an end to the means of sharing the cost of this system. However, we don't believe that commercialization, per se, is in fact the end purpose of remote sensing. Continuity of this kind of program in the United States is of the utmost importance.

It matters little to us as a user group where the hang-up lies in the present spate of finger-pointing over the budget payments. We simply believe the government must not renege on this effort which it initiated. In the long run we support continuity of Landsat-type civil, land, and ocean remote sensing programs, as I mentioned before.

I would like to say that in my written statement as asked, we presented some information on the use of Landsat data in oil and gas exploration and engineering projects. In the interest of time, I won't repeat that here, but I will say that we fundamentally look for surface mapping features with the satellite data. And this is mostly looking for structural anomalies or surface anomalies in vegetation and soils.

It is still nothing more than a mapping tool for us, and therefore, it is an indirect source of data for exploration and engineering problems. But we have found over the last 10 years, it can be very useful in many instances.

A comment is that we have come a long way since 1972, the launch of Landsat-1. But as I'll mention in a minute, one of the problems of the development of the use of this remote sensing technology is that in our community we need additional sensors which have not yet been provided by the data suppliers. This we hope will happen, both in the United States, and in Japan and France and elsewhere under the assumption that we can acquire that data.

One other point I wish to comment on that was pointed out by Mr. Nichols in Tuesday's testimony is that we are still on a learning curve. He said 10 years between the availability of data and development of a full market. It's at least that, if not more, in our experience.

An important part of this learning process should be the continued support, independent of Landsat 6 and 7 issues, of the kinds of centers of national excellence for remote sensing or cooperative institutes for applied remote sensing such as have been started NOAA, and I hope that Dr. Taranik will speak to that later on. An encouraging sign within the industry, however, is that after some time we are being to see operational use of remote sensing rather than simply R&D experimentation.

I was asked to compare the usefulness of United States, French, and Japanese, and ESA civil, land, and ocean remote sensing systems. And in my prepared testimony, if you have it before you, is a chart which I would like to quickly refer to.

To simplify, what we think of the importance of these technologies, in the left-hand column were the requirements as expressed by an ad hoc group of geologists in Flagstaff in 1976. In addition to the bands already on the multispectral scanner for Landsat 1 and 2, we argued for, or said that we needed shortwave infrared bands sensitive to clays and minerals and other kinds of—clays and carbonates and other kinds of minerals. I'll wait for you if you have it, because I do want to point to this chart.

And on the chart you'll find the recommendations to add to the MSS in 1976 marked by the asterisks. We also asked for thermal IR bands which, at that time, were considered to be somewhat of a distant technology. And we asked for 10 to 30 meter resolution that should read, as the range of resolutions useful for geology work.

In addition, we argued on behalf of stereoscopic capability, and very importantly, a global radar data set to see different kinds of information and also to penetrate clouds. This is in addition to radar's use on oceanographic studies.

If you look at the chart—I'm sorry, it's a very confusing nature—but mainly what I wanted to point out here is if you look in the 1991 timeframe, on the assumption that Landsat 5 and 6 are dead, and if we don't solve the Landsat-6 and 7 problem today or darned soon, Landsat 6 may not be flying in the 1991 timeframe.

In any case, on that assumption, then clearly the best geology satellite data is under the Japanese JERS satellite. And the reason for that is that it was designed from the ground up as a geology satellite to explore for oil and gas and minerals for the Japanese interests worldwide. Therefore, it has on it, obviously—or I shouldn't say obviously—but has basically all of the requirements that we asked for in 1976.

I want to emphasize the GEOSAT committee has come to Washington every year since 1976 expressing our concern that we don't have these capabilities in the United States. Obviously, also we are becoming enthusiastic users of the data provided by this French SPOT system because of its stereo and high resolution capabilities.

The requirements that I've expressed in 1976 or were expressed by that ad hoc group at all. Perhaps there is more emphasis on spectral information now than there was in 1976, but we still need all of those fundamental requirements to do our jobs adequately.

In any case, one other comment on the different sources of data would be the fact that we've always, under the current statement, expressed support for the building of complementary and compatible data systems under the Open Skies and Non-discriminatory Access principles. We believe that every country building these systems is too expensive, and that sharing the data is greatly important to simply operating around the world as most of our companies do.

And by the way, the GEOSAT committee is supported by companies who are not in the United States and other companies developing Landsat use data as well as other satellite systems.

I would like to conclude, the last question that was asked of me, or at least lead up to my conclusion my making a comment or two on Landsat continuity and our concerns about global nondiscriminatory access to data. The principles of Open Skies and Nondiscriminatory Access to data are U.S.-led principles for what was a U.S.-dominated technology. It was expressed by giving away Landsat data, cost of reproduction, and developed a great following for remote sensing around the world.

It was finally best stated, as it is stated in the Landsat Commercialization Act of 1984. We believe, however, that the main reasons for other countries to comply with these principles is the fact that the United States has a major civil land remote sensing program. And that we have shared our data with them.

The fact that it may also be the best way to commercialize the sales, for example, for French SPOT, is another factor also. Both the French and the Japanese, in our experience, have always stated their intent to comply with these issues and we certainly hope that we will. We have many friends in both countries and we work with both systems, and with data we hope from both systems.

But I do want to make a point in the case of the Japanese JERS satellite. It was a satellite designed to acquire economic intelligence for energy and mineral resources for Japanese interests. Their final policy decision, based on my knowledge, has not been yet made for global data distribution. I feel strongly that if the Landsat program is allowed to fall on its face that this may influence what the Japanese intend to do with their data regarding open skies or nondiscriminatory access to their data.

The Japanese and the French clearly have built systems to provide economic information for their governments and their industry. And we believe it's important for us to do so and maintain the system in the United States, in order that we may continue also to share data with these countries under nondiscriminatory access. To do otherwise will allow countries later on, who may covet the economic intelligence that better systems will provide, to keep this data to themselves.

My last comments I'd like to make is that based on Tuesday's hearings where many people asked, how did the United States get into the mess on Landsat, and more importantly, how do we get out of it. Of course, I don't have any answers.

I do strongly believe that one reason is that there is no long term government industry mechanism for setting a target like the development of satellite remote sensing technology and then getting there in the United States. The French and Japanese have mechanisms clearly to do this successfully.

I've appended three rough initiatives to my testimony on other issues, but I think they're pertinent. And they are my concerns and belief that the National Council on Space should be reestablished and supported by government and industry and transcends four year presidential politics. A subset of that is a National Remote Sensing Policy Council we advocated last year in hearings in this room.

And third, I would like you to consider the advisability of developing a Remote Sensing Development Corporation to tie together basic science, applications R&D and commercial development of remote sensing technology in the United States. Thank you.

[The prepared statement of Mr. Henderson follows:]

STATEMENT OF
DR. FREDERICK BRADLEY HENDERSON III
PRESIDENT, THE GEOSAT COMMITTEE, INC.
NORMAN, OKLAHOMA
BEFORE THE SUBCOMMITTEES ON
NATURAL RESOURCES, AGRICULTURE RESEARCH, & ENVIRONMENT
AND
INTERNATIONAL SCIENTIFIC COOPERATION
OF THE
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

2 April 1987

Mr. Chariman and Members of the Subcommittees.

I am pleased to have been invited to appear before this hearing of the Subcommittees on behalf of the many members of the Geosat Committee world-wide, who are working towards the further development and useful applications of the Landsat-type land and ocean satellite remote sensing technology. Our testimony is in support of completing the U.S. Government funding of continued operations of the present Landsat 4 and 5 systems and the building of the follow-on Landsat 6 and 7 systems as intended by the 1985 contract between the Department of Commerce and the EOSAT Corporation as part of the U.S. Government's efforts to "Commercialize" the Landsat system. More importantly however, our testimony is in support of a U.S. Government and industry commitment to long-term continuity of civil land (and ocean) satellite remote sensing programs in the United States and for international compliance with and continuity of the U.S. Principles of "Open Skies" and "Non-discriminatory Access to Data".

Accompanying me today is Mr. Harry Stewart, Manager, Geoscience Applications, SUN EXPLORATION CO. and 1986/7 Vice Chairman of the Board of Directors of the Geosat Committee. Mr. Cole McClure, Manager, Engineering Geology, BECHTEL CORPORATION and Director of the Geosat Committee, is not able to be here today as indicated in the attached letter expressing his regrets. Mr. McClure, as well as Mr. Stewart and myself will be pleased to provide written answers to questions or any other pertinent information for the record if so desired by members of the Subcommittees.

We appreciate the opportunity to appear before the Subcommittee on Natural Resources, Agricultural Research and Environment as we strongly believe that Landsat provides necessary and useful new data to industry, government and academic endeavors in these vital areas of national interest. Furthermore, we believe that information derived from Landsat data in many areas is useful to the private industry, but perhaps more importantly, information from Landsat benefits the public sector in these areas and thus the general citizenary as well.

We are also pleased to appear before the new Subcommittee on Interational Scientific Cooperation. We believe that satellite remote sensing is and should be based on international cooperation including reciprocal exchange of data. Development of future civil satellite remote sensing technologies will benefit more people if it is done with a maximum of international cooperation. With cooperative applications and evaluations studies being conducted or proposed with remote sensing organizations in ESA, France, Germany, and Japan, the Geosat Committee looks forward to working with international data and is committed to international cooperation.

LANDSAT COMMERCIALIZATION

A few general comments are offered. We belive that the present government effort to "commerciaize" Landsat is a means to an end, that is to try to see if, after spending $1.5 Billion of tax payers money on development, this administration-declared operating system can be successful as a private sector system. The arguments for and against commerciaization have been argued and aren't repeated here (Henderson 1986, attached). We believe that the commercialization process as dictated by the U.S. Government can only succeed if the long agreed-on private sector transfer subsidy funding is provided by the Government.

It matters little to us where exactly the "Hang-up" lies or in the present spate of "finger pointing". We simply believe that the Government must not reneg on is agreed financial support needed to see it's own commercialization experiment succeed. If the government allows the Landsat commercialization effort to fail, then we will push hard to see that the government continues to run a Landsat program as called for byt the Landsat Commercialization Act of 1984. In the long run, our primary support is for the continiuity of the Landsat-type civil land and ocean remote sensing programs in the United States. We also support other countries civil land and ocean satellite remote sensing progams as long as they comply with the principles of "Open Skies" and "Non-discriminatory Access to Data".

USE OF LANDSAT-TYPE DATA FOR OIL, GAS AND MINERAL EXPLORATION AND ENGINEERING PROJECTS

(Excerpted in part from Ralph Baker, AMOCO; member,
The Geosat Committee)

Exploration for non-renewable resources using remote sensing methods, most commonly Landsat images and aerial photography and some SPOT images, relies on surface indicators of mineral deposits or oil and gas traps. Such evidence may be in the form of observable structural features in sedimentary regions of favorable petroleum host resevoir rocks, or natural seepage or alteration and attendant vegitation or gechemical stress; geomorphic anomalies or characteristic geological associations. Since any single line of evidence is usually incomplete (espceially for remote regions), subjective exploration models have been developed which compile, evaluate and predict mineral or hydrocarbon potential of a region based on the data that IS available.

The detection of economically significant petroleum and mineral deposits continues to be a major goal of remote sensing geologists. Hydrocarbon exploration from Landsat is typically being accomplished in industry using conventional photogeologic interpretation, where image features such as tone, color, texture, and feature geometry are interpreted in the light of the geologists experience and ground truth. A significant improvement in this information extraction process evolves from the development of interactive computer-assisted image enhancement and classification techniques which enabled geologists to detect subtle spectral variations in satellite images invisible to the unaided eye, but related to terrain features of potential interest.

Geological remote sensing relies on indicators which can be seen at the surface. These indicators fall into two general categories:

1. Surface Tonal Anomalies. Caused by geochemical processes (e.g., hydrothermal alteration, oxidation or reduction) which cause subtle changes in the surface texture or color, stress on overlying vegitation, and diagenetic changes in mineralogy.

2. Structural Anomalies. Surface features indicating geological structure at depth. This includes deviations in drainage patterns, lineaments (faults or fractures), alignments of lakes, sag ponds, domes, basins, etc.

Geological remote sensing for construction, engineering, and environmental projects such as power plant, dam, pipeline and transportation corridor sitings similarly rely on identification of surface structural and tonal patterns and anomalies.

The use of satellite remote sensing technology by the non-renewable resources industries has come a long way since the launch of Landsat 1 in 1972. But for many users, use of remote sensing is still in the developing stage. This factor is compounded by the fact that needed remote sensing capabilities for geology have only recently been partly met by the satellite producers (see chart, discussion below). For the last six years the minerals industry as well as the petroleum industry have been gutted by the effects of long term low metal and oil prices. The effect of this industry wide depression and the slowness to develop the needed sensors (e.g., global radar) has slowed the necessary industry applications R&D needed to understand what can actually be done with the technology. The ten year learning curve gap between sensor avalibility and full market utilization as dipicted in Warren Nichols, SBRC testimony of 31 March 1987 before this Hearings is quite real within the Geosat companies. Thus, we are still learining what information can be extracted from the Landsat Thematic Mapper. We are only beginning to obtain SPOT data to begin to learn how it can be used in everyday operations. This learning process could be enhanced by stable funding for centers such the new NOAA Cooperative Institutes for Applied Remote Sensing (CIARs).

An encouraging sign, however, is the fact that in spite of economic exploration turn down, Geosat companies are seeing use made by their operating divisions, which is adding some credibility to this new technology in the oil, gas and mineral industries. This operational use is expanding as companies learn how to integrate information derived from remote sensing data with other informantion , i.e. through GIS and other information systems, to provide "management -friendly" information for industrial decision making.

COMPARATIVE USFULNESS OF U.S., FRENCH, JAPANESE, AND ESA CIVIL LAND/OCEAN SATELLITE REMOTE SENSING SYSTEMS

In May of 1976, an ad hoc group of 45 geologists from industry, government, and academia held a workshop to define what sensor capabilities for geological mapping should be added to the multispectral scanners (MSS) of Landsats 1 and 2 with four VNIR (visible and near infrared) bands at 78m resolution. These recommendations are shown on the attached chart. They include the addition of geologically sensitive SWIR (short wave infrared) bands for clays and carbonates and other rock and soil minerals, 10-30m spacial resolution for better feature dicsrimination, stereoscopy for 3-D photogeologic, geomorphologic, and topographic interpretation, and radar for soil moisture, surface roughness, and cloud penetration and topography. These sensor capabilities were considered state-of-the-art in 1976 needing only a political decison for their funding and development by NASA at the time. Multispectral thermal infrared (TIR) bands for rock and soil silica and silicate mineral discrimination were recommended, but in 1976 were condidered far-off, like 10 years (to 1986) for development.

These recommendations were given to NASA, but not implemented (except for the 30m spatial resolution and SWIR bands of the Thematic Mapper of Landsats 4 and 5), because of a lack of a government agency requirements for such a system. Industry at this time was not prepared or able to fund such a satellite system on its own, especially if it could not control the use of the data amongst the industrial investors. As a result of NASA unwillingness to develop such a geologically oriented satellite, the Geosat committee was formed to help the government develop reasons for a U.S. geology satellite.

Since that time, the thinking within the Geosat Committee companies has changed little. One reason for the slow growth of the remote sesning market from the point of view of the non-renewable resources industires is that our sensor requirements have only partially been met to date. As such, it still has limited value.

Comparison of these 1976 requirements, which are still valid today, with the known and proposed U.S., French, Japanese and ESA systems is a fair measure of their anticipated usefulness to the non-renewable resource community. We also believe that these requirements will serve many other users in other disciplines in industry, government , and in academia.

Of the present or funded systems likely to be operating in 1990/91 , there are the Frence SPOT 3/4 satellites, ESA's ERS-1 radar satellite, and Japan's geologically dedicated JERS-1 satellite. This assumes that Landsats 4/5 are dead and that due to bugetary and funding foul-ups in 1986/7 and perhaps 1989, Landsat 6 is not yet operating in 1991. If this is the case, it can be seen that the Japanese geology satellite JERS-1 should be the best data set for the non-renewable industries and others - If - the data is distributed globally with nondiscriminatory access. New information from Japanese JERS-1 data will be derived from the L-Band SAR radar and from three spectral bands in the 2.0-2.4 region partly equivalent to the single broad 2.2 Landsat TM band (see Figures 1 and 2). At the same time, SPOT 4 with one new SWIR band will continue to supply excellent high resolution (10 and 20m), stereo data; while the ESA ERS-1 C-band SAR radar will be a major contributor to land and ocean remote sensing.

If, the present Landsat funding mess can be resolved this year, and if some of the additional sensor packages proposed by EOSAT and presented at the 31 May portion of these Hearings are included, then Landsat 6 may provide additional important data possibly in the 1991 time frame to "compete" with SPOT 3/4, ERS, and JERS-1.

Clearly, for the non-renewable resource industries as well as other users, the Japanese JERS-1 satellite with its radar and expanded TM geology bands will satisfy many of the geology communities remote sensing requirements. This situation makes the addition of the Thermal IR package, the ocean SEA-WIFS, the wide area WIFS and the Advanced Landsat 32-band spectral packages proposed by EOSAT all that much more important for inclusion on Landsats 6/7.

.In comparing these systems, it is important to note that we have long supported the importance of having several operational land/ocean satellite remote sensing systems which provide compatible and complimentary data to the world user community under the "Open Skies" and Non-discriminaroty Data Access" Principles. The community represented by the Geosat Committee uses world wide data for world wide non-renewable resource exploration, development, and engineering. We have used and will continue to use all available data and intergrate these data sources as is appropriate to the work at hand. No one sensor does it all and no one system yet planned has everything that is needed. And finally, no one system is likely to get the necessary global coverage except over long term-many satellite programs. Even today, for reasons of technology, economy, and politics, all of the world has yet to be sensed on a cloud-free basis by Landsat Thematic Mapper after five years. Several satellites are required for complete global coverage of four seasons needed by the non-renewable resources uses community.

LANDSAT CONTINUITY AND GLOBAL NON-DISCRIMINATROY ACCESS TO DATA

The principles of "Open Skies" and "Non-discriminatory Access to Data" were established by the United States beginning in the 1950's. With respect to civil land remote sensing satelites, they became part of U.S. law with the passage of the "Landsat Commercialization Act of 1984". These principles are further defined by NOAA regulations authorized by that law and still being written and promulgated. The main point here is that while the U.S. has encouraged compliance by other countries building such systems, they do not come under U.S. jurisprudence. It appears to us that the main reason for other countries to comply with these principles, especially for non-discriminatroy access, is the exsistence of the Landsat program and the U.S. policy of first providing the data to anyone at cost of reproduction and then under a higher common price for "commercialization" under the non-discriminatory access principle. The French apparently are complying with the "non-discriminatory access" principle at present and state that they plan to continue such policy for future SPOT satellites. The Japanese have often stated publically that they intend to comply with these policies. The Geosat Committee has worked over the years with agencies and companies in both countries on the assumption that they will comply with these principles and we have expressed our concern for and the importance of their compliance when and whereever possible.

In the case of the Japanese JERS-1 satellite, we are still conerned about their data distribution policy. It should be understood that the JERS-1 satellite was specifically designed to meet the mission for MITI (Ministry for International Tradce and Industry) to provide a truely geologically dedicated satellite to acquire economic intelligence on global energy and mineral resources for their own countries critical resource requirements(over 85% dependent on non-Japanese sources for energy and mineral needs). This requirement could influence their final global data distribution policy which as of this date has not yet been finalized by the Forieign Ministry and Prime Ministers Offices. It has been and remains our sincerest hope that the final policy will be in compliance with global non-discriminatory access to JERS-1 data however they decide to distribute it.

It is clear that both the French and Japanese systems are built to porvide their governments and their industry with this important technology and the economic intelligence that can be derived from it. We believe that the Unitrd States must maintain a civil land/ocean remote sensing satellite capability in order to continue to influence our allies and trading partners to comply in the future with these basic civil remote sensing principles. If we lose a continually developing Landsat program through current government-industry squabbling over who should pay for it and a clear lack of having a common long term government/industry goal for the U.S. development for civil satellite remote sensing technology, then I believe the continuity of international "Open Skies" and "Non-discriminatory Access" may be in jeopardy in the future as countries and companies come to covet the economic intelligence that better systems can provide in the future. Such an environment is hardly conducive to U.S. attempts for further civil remote sensing development in the Space Station Era, with or without international cooperation.

CONCLUDING COMMENTS

Throughout the first days testimony at these Hearings on 31 March, many people posed the question of how did the U.S. get in to the present mess and more importantly, how do we get out of it.

I believe strongly that one reason is that there is no long-term government/industry mechnanism for setting a target like the development of remote sensing technology and then reach that target. Both the French and Japanese clearly have such mechanisms. Mayby their mechanisms aren't American, but they work and seem to be making a mockery of whatever decision system we think we have in this country.

I have appended three rough initiatives which may in some form assist the U.S. decision-making processes in the future. They include re-establishment of a National Council on Space composed of industry and government that transcends four year Presidential election politics, a National Remote Sensing Policy Council, perhaps as a subset of a revitalized National Council on Space, and a Remote Sensing Development Corporation to tie together basic science, applications R&D, and commercial development of civil land/ocean remote sensing as it may best serve the United States.

GEOSAT REQUIREMENTS Flagstaff 1976	Landsat 4/5 TM	Spot 1,2,3	JERS-1	ESA/ERS	Landsat 6/7	Spot 4
	Present	Present	Funded	Funded	Proposed	Proposed
Time	87-88 (+)	87-90	91	89-90	91-	91 (?)
VNIR #s	3#	3#	3#	-	3#+	3#
* SWIR #s	2#	-	4#	-	2#?	yes
* Thermal IR #s	-	-	-	-	yes?	-
* 10-20m Resolution	30m	10,20m	18m	25m	15,30m	10,20m
* Stereo	-	x-track	down track	-	down track	-
* Radar	-	-	L#	C#	-	
Other	-	-	-	-	CWIFs	-

EFFORTS TO PRODUCE SEVERAL DISCRETE BANDS IN ELECTRO OPTICAL SCANNERS OVER THE 2.0 TO 2.4 MICRON WAVELENGTH RANGE FOLLOW MANY YEARS OF FIELD SPECTRAL ANALYSIS OF ALTERNATION MINERALS. THIS IS A KEY TO DETECTION FROM AN AIRBORNE OR SPACEBORNE PLATFORM OF MINERALS TIED CLOSELY TO ECONOMIC DEPOSITS OF GOLD, OTHER PRECIOUS AND INDUSTRIAL METALS AND HYDROCARBONS. SPECIFICALLY, HYDROTHERMALLY ALTERED CLAYS CAN BE DISTINGUISHED IF THERE ARE DISCRETE BANDS FROM 2.0 μ TO 2.12 μ, 2.13 μ TO 2.27 μ AND 2.27 μ TO 2.40 μ. ADDITIONALLY, CALCITE CAN BE SEPARATED FROM CLAYS WITH THE 2.35 MICRON CENTERED BAND. DIAGENETIC CALCITE HAS BEEN TIED TO HYDROCARBONS SEEPING TO THE SURFACE OVER OIL FIELDS.

o Long Term Bipartisan Space Policy

- Concern: As the United States and the free world enter the 21st. Century, space will become a dominant economic, political, military, and philosophical force in the national security and economic well being in the United States. Such a force will transcend cyclical presidential and congressional election politics. As with the Joint Chiefs of Staff, the President's Economic Policy Council, and other forms of presidential council, the Presidency will become more and more dependent on long term space policy and implementation through govenrment - industry coordination and cooperation to assure U. S. dominance in space of the future.

- Initiative: Establish a continuing National Space Council with Governnment, Industry and Academic participation to provide long term guidance to the President in order to best utilize man's access to space in the best interests of the American People.

F. B. Henderson III
21 February 1987

o Satellite Remote Sensing

- Concern: The international use of near earth to remotly sense its atmospheres, oceans and land masses from satellites has become recognized as a fundamental source of economic as well as political intelligence for governments and industries of the world. U.S. civil land and, perhaps, ocean satellite remote sensing systems are faltering because of funding competition with military systems and lack of civil government user support in the current an effort to commerialize such systems, perhaps prematurily. France and Japan, oin the other hand, have regocnized the national value of the economic intelligence that can be derived from such systems and have established and are implementing national policy to develop such systems through integrated government - industry programs.

- Initiative: Establish a National Remote Sensing Policy Council to provide for long term government - industry policy and implementation to assure the continued development of civil satellite remote sensing technology for the benefit of both the governemnt and private sectors of the United States.

F. B. Henderson III
21 February 1987

Remote Sensing Cooperative Research and Applied Development

o Concern: Critical to long term satellite remote sensing technology development and commercialization, where appropriate, is the need for cooperative research and applications development between government, industry, and academia. No one group can alone accomplish all that needs to be done. A common problem today is the confusion that reigns between who should develop satellite systems, ground systems and the value added industry, and therefore, who should bear the brunt of funding what must be done to compete internationally. Curently, there is a growing proliferation of centers of R$D and commercial development, all vieing for scarce government and industry funding and with no common goals or directions.

- Initiative: Establish a Remote Sensing Development Corporation (RSDC) which would integrate necessary cooperative government, industry, and academic R&D and applied remote sensing. RSDC could work in coordination with the Congressionally mandated "Unified National Plan" and be supportive thereof. Cost and direction would be shared between participating government agencies, remote sensing systems developers, the value added industries, the user community, and academia. Where appropriate, use would be made of existing centers. Models for such cooperative ventures include the Semiconductor Research Corporation, Durham, N.C. (SRC, Larry Sumney, President), and Microelectronics & Computer Technology Corporation, Austin, Tx. (MCC, Bobby Inman, past Chairman).

F. B. Henderson III
21 February 1987

Bechtel Civil, Inc.
Engineers - Constructors
Fifty Beale Street
San Francisco, California
Mail Address: PO Box 3965, San Francisco, CA 94119

March 30, 1987

Dr. Frederick B. Henderson
The Geosat Committee, Inc.
601 Elm Street
Norman, OK 73019

Dear Fred:

I wish to apologize for not being able to attend the House of Representatives Subcommittee meeting April 2, 1987. As you know, we feel that anything Bechtel can do to further encourage active participation by our government in the Landsat program will be helpful to U. S. industries competing in the foreign engineering service market. We feel that maintaining the open skies policy can only be assured by active U. S. Government participation in the future Landsat program.

The application of remote sensing in engineering projects is becoming more wide-spread. It is becoming more valuable with the greater resolution and the greater spectral range, for example the Landsat 4 and 5 images compared with the earlier Landsat data. The 10 meter resolution available from SPOT is also very helpful in our engineering projects. Our main use of remote sensing has been in corridor studies, i.e., pipeline and highway studies in foreign countries where maps are difficult or essentially impossible for U. S. companies to obtain. We have used remote sensing on Bechtel pipeline projects in China, India and South America; power plant studies in Spain and Taiwan; ground water resources studies in Africa and the Middle East.

Other U. S. engineering companies are also beginning to use remote sensing, especially in early stages of project studies.

Again, I would like to encourage more active U. S. Government participation in that part of the Landsat program that private industry cannot possibly afford.

Sincerely,

Cole

C. R. McClure, Manager
Geotechnical Services

CRM:mls

* Executive Committee
** Chairman

+ Elected Officer of the Corporation
++ Ex-officio Board member

1987 BOARD OF DIRECTORS

THE GEOSAT COMMITTEE

Dr. Anthony R. Barringer
Chairman
BARRINGER RESOURCES
25060 Montane Drive West
Golden, CO 80401
303/526-1115

* Dr. Kenneth W. Ciriacks
Exploration Manager
AMOCO PRODUCTION
P.O. Box 3092
Houston, TX 77253
713/556-4414

* Dr. Norman Guinzy
** Manager, Exploration Research & Technical Service
MOBIL RESEARCH & DEVELOPMENT
P.O. Box 891047
Dallas, TX 75381
214/851-8204

Dr. Michel T. Halbouty
President
HALBOUTY ENERGY
5100 Westheimer Road
Houston, TX 77056
713/622-1130

Dr. Cortez Hoskins
Vice President Exploration
UNOCAL RESEARCH CENTER
P.O. Box 76
Brea, CA 92621
714/528-7201

Dr. John MacDonald
President
MACDONALD-DETTWILER ASSOCIATES
3751 Shell Road
Richmond, B.C.
CANADA V6X 2Z9
604/278-3411

Mr. Cole McClure
Manager, Engineering Geology
BECHTEL CORPORATION
P.O. Box 3965
San Francisco, CA 94119
415/768-8214

Officer of the Corporation
Secretary of The Geosat Committee
Gary Ballew
Senior Exploration Geologist
PHILLIPS PETROLEUM
262 GB
Bartlesville, OK 74004
918/661-9732

Mr. Robert Porter
President
EARTHSAT
7222 47th Street
Chevy Chase, MD 20815
301/951-0104

+ * Dr. Mark Settle
Director, Exploration Techniques
ARCO EXPLORATION & PRODUCTION RESEARCH
2300 West Plano Parkway
Dallas, TX 75075
214/754-3667

+ * Mr. Harry Stewart
Manager, Strategic Geoscience Applications
SUN EXPLORATION
P.O. Box 2880
Dallas, TX 75221
214/470-1950

+ * Dr. Irwin R. Supernaw
Senior Scientist
TEXACO
P.O. Box 425
Bellaire, TX 77401
713/432-3382

Dr. James V. Taranik
Dean
MACKAY SCHOOL OF MINES, UN-R
Old Building, Room 104
Reno, NV 89557
702/784-6987

Dr. Robert G. Todd
Manager, Basin Exploration Division
EXXON EXPLORATION & PRODUCTION
P.O. Box 2189
Houston, TX 77001
713/965-4428

Mr. Oliver Warin
Exploration Manager
UTAH INTERNATIONAL
550 California Street
San Francisco, CA 94104
415/981-1515

++ Dr. Frederick B. Henderson III
President
The Geosat Committee
601 Elm Street, Room 438C
Norman, OK 73019
405/325-3329

HEAD OFFICE
#206 1750 COURTWOOD CRES
OTTAWA CANADA
BUREAU CENTRAL
1750 COURTWOOD CRES PIECE 206
OTTAWA CANADA

MAILING ADDRESS
BOX 5378 STATION F
OTTAWA CANADA K2[illegible]
ADRESSE POSTALE
C P 5378 SUCCURSALE F
OTTAWA CANADA K2[illegible]

THE CANADIAN INSTITUTE OF SURVEYING
ASSOCIATION CANADIENNE DES SCIENCES GÉODÉSIQUES

March 11, 1987

The Honorable Malcolm Baldridge
Secretary of Commerce
Herbert C. Hoover Building
Washington, D.C. 20230

Dear Mr. Secretary:

The Canadian Institute of Surveying and Mapping is a national association of 2500 members representing the scientific and technical interests of the surveying and mapping community in Canada. We are taking this unusual step of writing to you as a leader in the U.S. Government because the decision made by your Department regarding the LANDSAT program will have a great impact in Canada.

Since the launching of the first satellite of the LANDSAT series in 1972, Canadian governments and industry have become increasingly dependent on LANDSAT images to support many important programs and projects. For example, in fiscal year 1986/87, Canadians purchased approximately $850 000 worth of LANDSAT products and paid a similar amount to the United States as royalties and fees. While most of the data (56% of the total) is used to produce land information for operational public service programs, industrial uses (38%) are far from negligible, the rest (6%) being purchased by educational institutions. The medium spatial resolution and detailed spectral information data provided by LANDSAT (as opposed to the high spatial resolution and low spectral information data produced by the recently launched French satellite SPOT) is particularly useful to monitor and map Canada's hinterland. For example, of all the LANDSAT applications in Canada forestry accounts for 22%, geology 14%, wildlife studies 10%, ice investigation 9%, and cartography 6%.

Canada therefore has a strong interest in the continuation of the LANDSAT program. Furthermore we believe that the market for Earth observation satellite products is still in its infancy in the United States and Canada and will grow to become a profitable activity provided that data continue to be made available. We think that it would be extremely regrettable if the American Government, after having had the vision to launch the first Earth observation satellite fifteen years ago, should now decide to abandon a program that is beginning to bear fruit in terms of broadening use and rapidly expanding private sector activity in both of our countries.

Yours sincerely,

G. Babbage.

G. Babbage,
President

c.c. Congressman James Scheuer
Senator Ernest F. Hollings
Senator Warren B. Rudman

Mr. Hall. Thank you, Dr. Henderson. I surely think that there's a lot of need in your very last paragraph stating your concern in your prepared statement, and I'm sure the group will enjoy hearing it. And this bell goes off when you say things that we don't like to hear, like you don't have an answer for us. [Laughter.]

But thank you, and recognize Mr. McCandless.

Mr. McCandless. Thank you, Mr. Chairman, members and staff. I represent the National Ocean Industries Association. We have over 400 members in ocean industries ranging from oil and gas to fisheries to nearly every industry you can consider in that environment. And we're here today to talk to you about our interests in remote sensing as it applies to our industry base.

I was asked in your letter to address two key issues; the Landsat program and the ocean color imager. And I'd like to do that briefly and then go on to some larger issues that we feel are very important to our members.

First of all, regarding Landsat, we support the remarks that Dr. Henderson has already made. I'd like to just punctuate that by saying, this year the actions of the Office of Management and Budget and the Administration have placed the program and the whole EOSAT commercialization activity in limbo. A number of members like to use the word disarray when we talk about what we see happening. I'd almost use a stronger word; my word, disgrace.

I think it's disgraceful that this bold opportunity that was started very successfully by NASA in its proof of concept stage many years ago and was a flagship of our whole remote sensing activities. I was involved in other activities relating to the marine environment, but Landsat really led the way in having the public exposed to what we can do. And now we're looking at this system pretty much on the rocks. And we think it's a disgrace and that the situation should be reversed.

Against this backdrop of indecision, talking about the ocean color imager is a little hard to do. I'll say a few words about our interest in it. But frankly, the real issue is that augmenting sensors, other sensors that could take advantage of platforms like EOSAT, Landsat or the other platforms being sponsored by the government, are all in jeopardy right now.

If you look back at some of the sensors that we put in space that are valuable to the marine environment, most of them have not been flown after the proof of concept phase. A good example is Seasat. We're still waiting for successors to that program, and as you pointed out, Mr. Chairman, the French, the Japanese, the European Space Agency have taken our inventions and progressed with them.

A few words about the ocean color imager since you asked me to address it. We have looked at the applications of that data set based on the coastal zone color scanner which was flown on the very successful Nimbus-7 satellite. And just listing the kinds of things that we feel that sensor would provide if it were put into an operational environment, there was clearly a lot of fisheries applications that were looked at as part of the Nimbus-7 experience.

The Pacific tuna fleet and others used the data very successfully in locating and harvesting and avoiding inefficient voyages looking for the fish. So fisheries research and applications is an important one.

Certainly the offshore petroleum and marine mining activities have used the data to visualize flow of ocean currents. That's well documented. Looking at the abundance of marine resources in the exclusive economic zone is certainly something that you could do with the ocean color imager. Environmental quality observations for impact statements to the environment is something that that instrument supports, and certainly global climate assessment.

But again, without a platform to put such an instrument on or initiative like Landsat, it's a little bit of a moot point.

I'd like now to spend a minute or two on some broader issues that are important to our organization, and I would like to make them in the context of three basic subjects. The first one, which was made very eloquently by you earlier is that although we've pioneered ocean remote sensing from space with Nimbus, Seasat, and other sensors, we've failed to take advantage of our discoveries.

Others, in fact, have taken advantage of our discoveries. As you know, there is an MOS mission in space now, the Japanese dedicated to ocean remote sensing. They've taken our imaging radar, synthetic aperture radar and they've planned a mission called JERS-1. The Europeans plan a similar mission to Seasat in the 1990's.

We have a mission called N-ROSS which has been, as you know, being looked at by the Navy but that's been on again off again. It's suffering the same kinds of indecisions that you see here. It doesn't seem to matter whether it's in or out of the government, those indecisions are still strangling us. So that's a key point.

The second point I'd like to make is that in spite of our delay in getting to remote sensing instruments of high value to the ocean industries, we should be making plans to take advantage of the data sets being collected by others, and I don't see that happening either. That's a very important point. I have no objection to a broad-based set of program, our own and international programs dedicated to ocean sensing.

But as they took advantage of our missions, we should in fact be laying a groundwork to take advantage of theirs. That is not occurring.

And then thirdly, even if the proper facilities are established to assimiliate ocean data in the government, it's not always clear that the civil sector is able to take full and effective advantage of that.

So I'd like to leave with those three basic points. We support, again, the Landsat initiative. We certainly support N-ROSS and will continue to support any of these activities leading to improved ocean data in the civil sector. We appreciate the opportunity to brief this morning and encourage you to get some balance and projection in the use of these important remote sensing technologies. We need to be able to follow through. And that's the last comment I'll make.

[The prepared statement of Mr. McCandless follows:]

NATIONAL OCEAN INDUSTRIES ASSOCIATION
1050 Seventeenth Street, N.W., Suite 700 Washington, D.C. 20036

(202) 785-5116

STATEMENT BEFORE
THE SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT
AND
THE SUBCOMMITTEE ON INTERNATIONAL
SCIENTIFIC CO-OPERATION

A STATEMENT ON BEHALF OF
THE NATIONAL OCEAN INDUSTRIES ASSOCIATION
BY
SAMUEL W. MC CANDLESS, JR.
PRESIDENT - USER SYSTEMS INCORPORATED

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
WASHINGTON, D.C.
APRIL 2, 1987

The National Ocean Industries Association (NOIA) is the principal Trade Association for the industries engaged in ocean resource development. Many of our corporate members (over 400) are active in NOIA's Telecommunications Policy Committee which has focused on space applications which support maritime operations. NOIA is the foremost advocate for operational users of maritime satellite applications, including navigation, communications, and remote sensing. In a very real sense, our efforts are on behalf of the entire civil maritime community and not solely for the benefit of NOIA members.

Space applications issues of interest to NOIA members fall into three general categories: Ocean Sensing, Navigation, and Communications. My testimony is directed at Ocean Sensing issues.

I will concentrate on three basic points in my testimony:

1. Although the United States has pioneered ocean remote sensing from space, we have failed to take advantage of our discoveries. Instead of initiating programs helpful to ocean data users, we have delayed them, and, in some cases, propose to cancel useful systems such as the LANDSAT system. NOIA is committed to the continuation of this important National asset and supports the commercialization approach begun with government support but now seriously endangered, to the point of extinction, by government inaction.

2. In spite of our delay in establishing operational space-based ocean remote sensing systems, other countries are proceeding. As a result, a sharp increase in ocean and Arctic data will occur at the end of this decade. The United States is making plans to collect and use some of this data, but my colleagues in NOIA are concerned about our ability to take full advantage of these new systems. With our own programs in disarray, we need to establish new facilities and systems to handle this data as well as firm agreements with foreign governments and institutions, allowing us to gain access to these useful data sets.

3. Even if the proper facilities are established to assimilate useful ocean and Arctic information into government systems, the transition from the government to the civil sector is not always effective. Issues such as civil use charges and shared cost have been discussed but do not focus into working systems and agreements. Much improvement is needed in these areas.

I will address these issues in sequence.

THE UNITED STATES OCEAN SENSING INITIATIVE

As a general consideration, NOIA members perceive a crying need for a definitive national plan for space applications programs.

The government policy-making apparatus is in serious need of repair, particularly with respect to ocean space applications. The budget process seems incapable of producing an integrated civil-military program or an appropriate balance between research and applications. Space research and applications are inherently multiyear operations which cannot achieve maximum effectiveness if weighed in the year-at-a-time budget process. The national interest demands development of a national plan which integrates these widely varying requirements in light of budgetary realities.

NOIA members are aware that ocean sensing technology has progressed to the point where comprehensive satellite data could enable a quantum improvement in ocean weather forecasting which in turn would be a major benefit to offshore operations and safety.

Despite the demonstration of this technology by SEASAT in the late 1970's, the ocean community is still waiting for a viable operational system. We attribute this deficiency to an ineffective policy making apparatus in government. Ocean related space applications have lagged behind other applications, partly because the ocean constituency and its government advocates have not been as vocal or as effective as those of other sectors.
NOIA members are also concerned about an imbalance between technology development and applications programs in national resource allocations. The European and Japanese civil space programs are dedicating roughly one third of their space budgets to applications programs of direct benefit to their industries. In terms of real dollars, the Japanese and the European programs are funded better than the present United States applications programs. NOIA members feel strongly that a more appropriate balance needs to be established.

THE LANDSAT PROGRAM

This year, the actions of the Office of Management and Budget (OMB) and the Administration have placed the LANDSAT program and the EOSAT commercialization activity in limbo. Earth observation is one of the great success stories of the entire space program. It is ironic that LANDSAT is floundering in a morass of indecision and misperceptions based on obsolete notions.

At the center of this problem is the transfer of the LANDSAT from government to the private sector. Federal policymakers were persuaded to favor the transfer by the claims of LANDSAT advocates who promised large commercial markets for the system's products. Those claims ultimately led to a decision to transfer LANDSAT to private industry.

Early claims for the size of the private market were exaggerated and government agencies' refusal to guarantee any purchases of LANDSAT data from EOSAT permitted the government to avoid any responsibility for ensuring its continued supply. In light of a recent government decision to purchase French SPOT data, this situation is at least bizarre. The plight of the program continues in the same vein. Inconsistencies in the Landsat program abound. For example: OMB directed the National Oceanic and Atmospheric Administration, which was managing LANDSAT during its transition period, to raise prices for the data; at the same time, OMB restricted the budgets of federal agencies that used the data. These agencies were the same ones that most needed LANDSAT's product in order to fulfill their governmental duties: the Departments of Agriculture and Interior, the Agency for International Development, and various Defense agencies. In addition, private applications also exist, such as mineral and energy surveying. Viewed with a proper perspective, the data LANDSAT gathered was mapping data that governments have always provided. To continue to ignore the public-private nature of Earth observation and deny the government's need for the data is illogical and damaging to National progress.

The EOSAT Company, that won a stiff competition to take LANDSAT private, lacks any firm commitment of Federal support and the program's future looks dim at best. A leadership vacuum has exacerbated this breach of policy. By contrast, the French SPOT system has significant government support and co-operation.

Against this backdrop of indecision, augmenting sensors that might take advantage of the LANDSAT program are also lost. One such sensor is the Ocean Color Imager (OCI) derived from the useful data products gathered by the NIMBUS-7 Coastal Zone Color Scanner (CZCS). The CZCS ocean color products were developed to correspond as closely as possible to the at-sea measurement techniques employed by biological and optical oceanographers. The materials suspended within the oceans' surface serve as natural "tracers" which through their interaction with the fluid flow field reveal structures associated with open-ocean current boundaries, coastal fronts, eddies, and water masses. The value of these observations encompasses nearly all marine discipline areas which require near-surface descriptions of the structure and variability of the oceans' surface.

The OCI would provide unique regional and global observations for operational and scientific use. A summary of specific applications important to NOIA member interests include:

1. Fisheries Research and Applications - to predict fishing locations, as well as upwelling and other high productivity regions optimal for fish larvae growth.

2. Offshore Petroleum and Marine Mining - to visualize the flow of ocean currents and eddies for use in drilling and mining operations.

3. Exclusive Economic Zone - to estimate optical properties and phytoplankton abundance for marine resource and habitat assessment.

4. Environmental Quality - to provide observations of pollution and sediment inputs to assessment studies and environmental impact statements.

5. Global Climate - to understand the CO_2 problem in determining long range ocean productivity estimates.

The OCI is a necessary component of a successful oceanographic data collection strategy for the next decade.

SPACE-BASED OCEAN AND ARCTIC DATA

Beginning in 1987, a large number of foreign and domestic operational marine remote sensing systems will be placed in space. This planned capability represents a $2 billion investment in systems that will usher in an important era of capabilities. The impact will be similar to the extention of communications industries in space. The major question is going to be, "Is the United States prepared to participate and take advantage of this opportunity?"

At present, space-based oceanic data is limited to standard meteorological data over the seas produced by both the polar-orbiting and geostationary civil, and, to a lesser extent, military weather satellites. These satellites provide limited, but valuable, marine information.

The above products are widely used, but they are not adequate to meet all the needs of the maritime community. The immediate problem with the satellite-derived products is that they are based on sensors that operate in the visible and infrared portion of the spectrum, which are limited by cloud cover and lighting conditions (darkness). A further problem is that the current systems do not measure other major ocean parameters, such as wind and sea state.

Significantly more ocean parameters can be obtained from satellite measurements. The marine community requires all-weather, all-season data, such as that pioneered by the United States with the experimental SEASAT Satellite. The evidence produced by SEASAT and other proof-of-concept ocean sensing systems, such as Nimbus and GEOS-3, was sufficiently convincing that large ocean and Arctic remote sensing programs were initiated by foreign governments.

The availability of ocean and polar region data begins a steep upward course near the end of the decade when several important foreign and domestic programs place systems in space.

1) ERS-1. The operational successor to the SEASAT mission is being sponsored by the European Space Agency. Although the specific sensor design is different, the basic instrument complement is nearly identical to the SEASAT design. This mission is in a hardware development phase and will begin to return data from space in 1989/90.

2) MOS-1. The first Japanese entry into space-based ocean sensing is a modest mission using optical and passive microwave sensors. However, it represents the first of a series of similar missions that will be progressively more valuable. The first MOS mission was launched this year, with a second launch scheduled in 1990. The second mission will include active radar sensors.

3) JERS-1. Following MOS-1 the Japanese plan to launch a Synthetic Aperture Radar (SAR) imager, with some associated sensors, in the 1990's time period. This system will be capable of producing all weather high resolution images of ocean and polar regions.

4) N-ROSS. After backing away from this program earlier this year, the U.S. Navy recently re-established their plans for the Navy Remote Ocean Sensing System (N-ROSS) satellite, which builds on the SEASAT/Nimbus-7 heritage. The payload includes a SEASAT-type radar altimeter, an improved (six-antenna) scatterometer provided by NASA, a multi-frequency microwave imaging radiometer (SSM/I), and a lower frequency microwave radiometer. These instruments will provide all weather observations of sea surface wind velocity, wave height, temperature, sea-ice concentrations, and location of oceanic fronts and eddies. NOIA has been an active and consistent supporter of the NROSS program.

5) TOPEX. NASA's Ocean Topography Experiment (TOPEX) satellite is proposed for a 1990's launch into a 1300 kilometer (806 mile) orbit, with an inclination near 65 degrees. It will carry a very precise radar altimeter and orbit determination packages so that the surface topography of the ocean can be measured to an accuracy of 14 centimeters (5.5 inches) or less across an entire ocean basin. TOPEX data will provide an opportunity to significantly increase our understanding of large scale oceanic circulation, and augment the planned World Ocean Circulation Experiment.

6) NOAA/TIROS. A continuing series of NOAA polar-orbiting meteorological satellites is important to NOIA interests. In addition to a variety of atmospheric sounders such as the High-Resolution Infrared Radiation Sounder (HIRS), the satellites carry the AVHRR used for infrared sea surface temperature measurements accurate to 1°C (1.8°F) with 1 kilometer (0.62 mile) resolution; the French ARGOS positioning and data relay system; and the International Search and Rescue emergency beacon system. This system is continually under stress from OMB to reduce the two-satellite system to a single satellite. NOIA opposes this move.

As you can see, the burgeoning interest in ocean and polar region remote sensing from space will produce a deluge of new data near the end of the decade. The real challenge will be the complex negotiations that must take place between various U.S. civil and military government programs and, also, with other governments. U.S. marine data users will not gain access to new data unless their needs are known and fairly protected during negotiations and unless these negotiations are successful. In concert with these negotiations, new systems must be established to collect, convert and distribute this new data.

COMMUNICATION AND DATA TRANSFER BETWEEN THE GOVERNMENT AND CIVIL SECTOR

DOD has several environmental satellite programs which produce data of great value to the private sector. These data have traditionally been made available, typically through NOAA which has a mission to support the private sector. NOIA members have become concerned in recent years that NOAA had been unable to get budgetary support for the relatively modest expense of handling the dissemination role. Since DOD lacks a specific mission to support the private sector, the public could be denied access to valuable data products acquired at public expense. The national interest demands a resolution of this problem. It does not make sense to make a large investment in data acquisition and fail to follow through with product dissemination to the public. The government coordinating apparatus is very clumsy in this area, however. As an example, OMB officials have denied NOAA coordinated participation in DOD programs and, in forcing DOD to absorb the extra cost, have failed to achieve the national cost savings which the cooperative program would have enabled. All of the programs identified above will stress an already deficient system.

Congress has clearly shown its intent by providing NASA the civil space technology development charter and NOAA the civil space applications charter. They certainly recognize the need for a balance between these two vital civil space activities. However, the present administration through the Office of Management and Budget (OMB), has consistently refused adequate budget support for this new NOAA mission. This inaction has resulted in a defacto United States space policy that is directed solely to the development of technology with no clear intent of applying that technology for the benefit of the tax payer who is footing the bill. It is this policy that must be changed before the sharp increase in data occurs at the end of this decade.

NOIA ACTIONS AND RECOMMENDATIONS

ACCESS TO DATA - The primary interest of the NOIA Oceans/Sensing Subcommittee is to improve the availability of existing and forthcoming satellite data to the maritime and offshore industry. These data are as follows:

LANDSAT - Follow through with the commercial EOSAT initiative as it was originally conceived.

NOAA - Continue the two satellite system.

NROSS - Provision to the private sector of derived data from all sensors; i.e., wave height, wind speed and direction, precipitation, and sea surface temperatures.

ERS-1 - International agreements to provide SAR images and derived data from other sensors.

MOS & JERS-1 - International agreements to provide SAR images and derived data from other sensors.

Two data formats are required:

1) Near real-time for specified locations for operational needs

2) Archival data sets for applied research and climatological analyses

NOIA recommends that NOAA study the means and costs for providing near-real time access to satellite-derived data. If NOAA does not think the present Administration would absorb these costs and were to propose user charges, the data are of sufficient value that these costs might be recovered via user charges.

Satellite remote sensing of the ocean will evolve in much the same manner that satellite meteorology has progressed. It is also inevitable that the civil maritime community will find the data essential to business as marine applications become increasingly sophisticated and more and more sensitive to environmental perturbations. Marine businesses having a ready access to such data will survive and prosper. Nations with limited access to such data are not likely to keep up in the area of marine commerce.

CONCLUSION

NOIA appreciates the opportunity to brief the Subcommittee on Natural Resources, Agriculture Research and Environment and the Subcommittee on International Scientific Co-operation. We are mindful of the broad scope of your review and we recognize that it may be impossible to treat individual space missions in any detail, but we feel that the issues raised by NOIA should be addressed for your considerations. Specifically, NOIA has called for a national plan which lays out a balanced program of research and applications and a committment to ocean satellite programs which can make major contributions to the safety of life and property at sea. NOIA feels that a national plan is also needed to maximize the effectiveness of our limited budgetary resources and to resolve ambiguities in Agency roles. We can ill afford to dissipate the vast potential of our world leadership in space technology through an inability to cope with national management imperatives.

Mr. **Hall**. Thank you, Mr. McCandless. The chair recognizes Dr. Lillesand.

Mr. **Lillesand**. Thank you, Mr. Chairman, members of both subcommittees. We appreciate the opportunity to appear before you this morning to comment relative to the situation in the Landsat issue as expressed by members of the American Society of Photogrammetry and Remote Sensing. I will only attempt to summarize our statement for you this morning. You have the written document before you.

Before I get the substance of that testimony, however, I should point out that our membership comprises 8,000 people who come from all the value added service industry, remote sensing researchers, practitioners, members of state and local government, John Q. Citizen, alike. The organization is 50 years old. It is recognized as the largest professional scientific organization in the world in this area.

Hence, our interest in the commercialization activity, while certainly being financial, is more importantly technical and scientific. We have in previous venues expressed a consistent position on this issue, and that is that we have subscribed to the philosophy that commercialization is an inherently desirable if—and I underline the if—the process involves strong government support during the period of market development, and the program is conducted over the long term in a fashion that is considered to be in the best interest of the nation.

And we question the current uncertainty fitting within that purview. That is to say that we would submit that the current uncertainty surrounding the funding of the program is a situation that will ensure our not being able to capture the niche that we should in the international marketplace. This being a technology that we, in fact, created at tremendous taxpayer expense is now likely to have its benefits accrue to others.

The only way to capture that market is to change our current situation. The current situation is simply, lack of continuity, continued uncertainty. And believe me, in the marketplace that doesn't mix with competitiveness.

We have expressed this feeling to Secretary Baldrige in an earlier letter that was attached to your testimony. I would simply like to acknowledge at this point that we have received response to our letter and wish to enter into the record.

[Copy of letter follows:]

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

MAR 27 1987

Dr. Alan R. Stevens
President, American Society for
Photogrammetry and Remote Sensing
210 Little Falls Street
Falls Church, Virginia 22046-4398

Dear Dr. Stevens:

Thank you for your letter regarding the future of the U.S. land remote sensing program and data from the early Landsat program.

Congress appropriated $27.5 million in FY 87 to continue Landsat on the condition that we first obtain Congressional approval on a revised plan for the Landsat program. We submitted our revised plan to Congress on December 16, 1986. The Senate disapproved the plan in January 1987. We are discussing a possible alternative plan now with the Office of Management and Budget. Once a decision is made within the Administration we will advise Congress of any proposed revisions to our plan. Only after the Congress has approved a plan can we spend the funds.

Your second issue concerns the historical Landsat 1-3 data not converted to computer compatible format by the National Aeronautics and Space Administration (NASA) after September 1986 for lack of funds. NASA and the National Oceanic and Atmospheric Administration (NOAA) did contact other Federal agencies, private companies, and professional organizations for help in completing this program, but were unsuccessful. NOAA has arranged to continue this conversion program through March 1987 and will seek to preserve as much data as possible.

Thank you for your interest.

Sincerely,

Malcolm Baldrige
Secretary of Commerce

Mr. **Lillesand**. We've been asked to characterize the user community in areas different from those that you've already heard relative to the federal agencies and private practice and so forth. I'd simply like to characterize state and local government. And that is to say, that historically, the use of Landsat data by state and local government in the days of the early points in the program was very limited. We were limited by restrictive technology, 80 meter resolution. At that time we didn't have microprocessors sticking on the desks of state and local government. At that time we lacked the experience with the data, and certainly the general problem with the program being run on an experimental rather than an operational basis precluded states from substantial investment of time, effort and capital in the activity.

Currently, we are in a completely different situation. Number one, we've got improvements in the technology. I like to equate the current situation as, now we finally have the binoculars, previously we were using Coke bottles. When one compares 80 meter resolution to the 10 meter resolution of SPOT currently, we're talking about a 64-fold change in the minimum area observable on the ground. That changes, basically, the applications of space remote sensing from developing countries to domestic applications that are many and varied.

In addition to that, with EOSAT and SPOT present in the marketplace, we're beginning to evolve toward this commercial mode where we have international competition and a new value added service industry. We have microprocessors galore. We have, based on market surveys of a Facility Management Automation Incorporated, an estimate that $90.6 billion will be spent by state and local government on geographic information systems which will permit the merger of satellite remote sensing data with other forms of map information.

We are in a different information world at the state and local level. Some of the applications that we dealt with in my own state I've summarized in the testimony. They range from quantification of water quality to monitoring the coastal situation in the late Great Lakes, reinforcing the business about the utility for exploiting in a positive sense commercial fisheries opportunities. We've done county inventories of agricultural crops to assist in such programs as farmland preservation, irrigation management and soil erosion.

The point we're trying to make in summarizing all of this in our testimony is that the applications of this program are not solely industry and federal government. Rather, the implications extend very substantively down to the level of state and local government with respect to the efficiency and precision in the implementation of a number of natural resource programs at these levels. And we submit that the benefits therefrom accrue directly to the individual taxpayer.

Now having said all this, as a scientist, I'm compelled to offer yet another and I think broader and much more important perspective on this whole discussion. That is that the national and international scientific community has begun to crystallize the need for a better understanding of the entire earth on a global scale. This has been manifested in terms of budget priorities in NSF, a global Earth system science initiative is one that requires satellite data.

I'm in no personal position to judge the long term consequences of such complex and interrelated phenomena as global soil erosion, atmospheric and climatic variation, coastal and ocean degradation, tropical deforestation, desertification, acid rain, decreased genetic diversity, natural disasters, changing energy demand, variations in food and fiber supply on a global basis, and trends in global population distribution.

What I do know is that Landsat type satellite data can contribute to the solution and the understanding of all of those problems if we have the data base, if we have a national commitment to the program, and if we have the systems in place.

I think those benefits from a scientific standpoint make some of the discussion about how much we gain commercially pale in comparison.

Mr. HALL. And if we can get OMB to——

Mr. LILLESAND. If we can get OMB.

In conclusion, what we're seeing at issue here are several interrelated factors. Certainly the cost of the system is at issue. But the potential benefits that are derived by industry and all levels of government and in the earth system science understanding, in composite lead us to think that really what's at issue here are our leadership, our spirit, our prestige in space related activities. But not only that, our vision of the future.

As we enter the age of information replete with demands on a global data base, it seems imprudent to us to continue any semblage of uncertainty about maintaining one of our most basic sources of information about the earth. We don't want the program to just simply continue. What it needs at this point is increased commitment and enhancement.

I'll close with a statement that we introduced in 1983 that indicates that at least historically government has had little difficulty deciding on faith and belief in the ultimate value of science to make substantial investments in looking at planets other than the earth, but finds it somehow very difficult to bring itself to make even relatively modest investments in looking at the earth.

If there were ever a time to change this situation, we submit it is now. Thank you.

[The prepared statement of Mr. Lillesand follows:]

American Society for Photogrammetry and Remote Sensing
210 Little Falls Street
Falls Church, Virginia 22046-4398
(703) 534-6617

Testimony of Dr. Thomas M. Lillesand

Professor of Remote Sensing, University of Wisconsin-Madison

on behalf of the

American Society for Photogrammetry and Remote Sensing

before the

Subcommittee on International Scientific Cooperation

and the

Subcommittee on Natural Resources,
Agriculture Research and Environment

House Committee on Science, Space and Technology

April 2, 1987

Mr. Chairmen, members of the subcommittees, thank you for the opportunity to testify today and present the views of the American Society for Photogrammetry and Remote Sensing (ASPRS) on the current status of the commercialization of the nation's land remote sensing program and the long-term significance of this program.

Background on ASPRS

Before presenting the substance of my testimony, I would like to point out that ASPRS was established in 1934 and is the world's largest professional/scientific society devoted to the exchange of ideas and the dissemination of knowledge and new information about the application of the combined fields of photogrammetry and remote sensing. The society's 8,000 members come from across the spectrum of education, all levels of government, industry, and private practice. Hence, the society includes a broad cross-section of remote sensing researchers, remote sensing practitioners, members of the value-added sector, and end-users of remotely sensed data alike. In addition, ASPRS is affiliated with the American Congress on Surveying and Mapping (ACSM), a national professional society with 11,000 members in the fields of surveying, mapping, and geodesy.

One of our organizations' principal activities is the publication of scientific literature on the subject of remote sensing such as the Manual of Remote Sensing and the monthly journal Photogrammetric Engineering and Remote Sensing. These publications are recognized internationally as authoritative sources on the state of the art of remote sensing. Hence, our interest in the commercialization issue as an organization, while certainly financial, is more importantly, technical and scientific.

To highlight the scope of the aforementioned publications and our organization I would like to point out that the Manual of Remote Sensing is a document with contributions from over 200 authorities, not only on remote sensing theory and techniques, but on the application of remote sensing data to a host of resource management and environmental monitoring problems. Likewise, ASPRS's journal is distributed worldwide and contains up-to-date information on the application of remote sensing in fields ranging from agriculture, engineering, forestry, geology, and hydrology, to archaeology and planetary exploration. Attached to our testimony (Attachment 1) is an index of recent issues of our journal. The titles of these published scientific papers alone give one an appreciation for the breadth of current applications and research in remote sensing.

The ASPRS Position on Commercialization

Our organization's general concerns about the whole process of commercialization are a matter of record of various previous hearings dealing with the issue (including the House hearing of July 21, 1983 and the Senate hearing of March 22, 1984). We have consistently subscribed to the philosophy that commercialization of the Landsat program is an inherently desirable objective, if the process involves strong government support during the period of market development and the program is conducted over the long term in a fashion insuring the greatest service to the national interest.

We submit that the current uncertainty surrounding the funding of the program not only represents a breach of faith in the entire commercialization process, but also a situation that will insure that the U.S. remote sensing industry remains stillborn while existing and prospective foreign competition enjoys substantial success in the international marketplace. In terms of capturing our share of the global market for remote sensing products and services, uncertainty, lack of continuity, and competitiveness simply do not mix. Ironically, we seem to be on a decisionmaking path that will preclude our reaping the benefits from a highly technical industry that we in fact created--at considerable taxpayer expense. In other words, at a time when Congress is focusing on enhancing our nation's competitiveness, we are, by defunding Landsat, eliminating an important weapon from our domestic trade arsenal.

We have emphasized the above point in the attached letter (Attachment 2) we recently sent to Secretary Baldrige and other policymakers expressing our concern for the imminent data gap that will be caused by inaction on the part of the federal government.

Characterizing the Beneficiaries of the Landsat Program

The most immediately obvious beneficiaries of a viable U.S. remote sensing industry are those elements of our industrial sector who acquire, disseminate, and add value to remotely sensed data. Beyond this, one must consider the benefits that accrue to the end users of the data. Other witnesses testifying at this hearing have already articulated the value of remote sensing in commerical activities such as petroleum and mineral exploration. We wish to extend this discussion to consideration of the existing and potential value of remote sensing data at the levels of state and local government.

Trends in State and Local Government Use

Historically, the use of space remote sensing data at the state and local levels of government has been severely limited by such factors as:

-The restrictive technical design of the Landsat Multispectral

Scanner--having limited spatial (80m), spectral (4 wavelength bands), and radiometric (64 grey levels) resolution.

-The lack of training and computational capability needed to process the data in a local environment.

-The conduct of the program fundamentally as an experimental, rather than operational, activity--precluding provision of either standardized or tailored data products in a timely, reliable, economical fashion.

Currently, state and local governments are faced with an entirely different situation. They are beginning to evolve toward substantial application of remotely sensed data; particularly in the area of natural resource management. This evolution is associated with the following trends:

-Substantial improvements in the technical performance of current earth resource satellite systems--for example, the Landsat Thematic Mapper has 30m resolution (120m thermal channel), 7 wavelength bands, and records over 256 grey levels; SPOT-1 has 10m (or 20m) resolution and is a "pointable" system.

-Transition of space remote sensing activities generally from a research mode to a commercial one--including international competition and a new value-added service industry.

-Increased availability and utility of microprocessors for handling space remote sensing data in digital form.

-Proliferation of computer-based geographic (land) information systems capable of interrelating remotely sensed data with other geographically referenced land information.

-Increased need, across the entire local to global continuum of an information-based society, to obtain data about the land in a timely, synoptic, and efficient manner.

As a remote sensing researcher at a major Land Grant institution, I have had the good fortune to observe first-hand how Landsat data can be used at the state and local levels. A list of representative applications to which the data have been applied in our state includes activities as varied as:

-Quantification of the water quality (trophic status) of all public waters in the state to assist in lake preservation and restoration programs.

-Monitoring of the coastal processes operative along Lakes Michigan and Superior to assist in predicting the fate of toxic substances discharged into these waters and to further exploit the commercial fishery potential of lakes.

-Analysis of watershed land cover patterns to aid in streamflow estimation to assist in the design of bridges and culverts and assessment of non-point pollution impacts on receiving waters.

-Automated forest type mapping and detection of commercially significant pest problems (e.g. spruce budworm defoliation).

-Completion of county inventories of agricultural crops to assist in such programs as farmland preservation, irrigation management, flood/drought damage assessment, and soil erosion mitigation planning.

-Assessment of the food supply and habitat for various species of wildlife (e.g. deer and geese).

-Analysis of potential nuclear waste disposal sites and assisting in the mapping of the surficial glacial geology of the state.

-Preparation of medium scale image maps directly from the satellite data to support a range of resource mapping activities.

The point we are trying to make in summarizing the above trends and applications is simply that the present and prospective beneficiaries of our land remote sensing program are not solely industry and the federal government. Rather, the implications for remote sensing technology extend very substantively into the efficiency and precision of numerous programs administered by state and local government--which in turn impact the individual taxpayer.

Considering the Bigger Picture

As a scientist, I am compelled to offer yet another, broader, perspective on this whole discussion. That is, that the national and international scientific community has begun to crystallize the need for a better understanding of the entire Earth System on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all time scales. This initiative has been variously termed as inquiry in "global habitability", "global integrity," "global sustainability," or "Earth System Science." Call it what you will, it is becoming increasingly clear that the future quality of life on earth is premised on a much deeper and more holistic understanding of the physical, chemical, and biological processes operative on this planet.

I, frankly, am in no position to judge the long-term consequences of such complex phenomena as global soil erosion, atmospheric and climatic variation, coastal and ocean degradation, tropical deforestation, desertification, acid rain, decreased genetic diversity, natural disasters, energy demand, food and fiber supply, and global population distribution. What I do know is that Landsat-type satellite remote sensing can play a central role in better understanding all of these phenomena if we have the systems and the research capacity to tackle the problem. And, the potential socioeconomic and scientific benefits defy quantification.

Landsat vis-a-vis SPOT and Other Systems

It is clear that if the Landsat program is not continued, many data users will begin to rely exclusively on the SPOT program for their data products. In this light, we wish to point out that there are distinct advantages to having both Landsat and systems such as SPOT operating simultaneously. For example, in many respects these systems are complementary technically. That is, SPOT has better spatial resolution than the current Landsat Thematic Mapper, but the Thematic Mapper senses in various wavelength bands that SPOT does not. Also, it is possible to merge the data from both systems, using appropriate ground data processing procedures, and develop products unavailable from either system independently. Additionally, the image coverage patterns of the two satellite systems are different.

Another important advantage to having complementary systems is decreased vulnerability to gaps in the supply of data due to such factors as technical failures, launch delays, competing demands for data acquisition, cloud cover, etc. This assurance of the continuity of data is not only important to further developing the user base, it is critical to securing the capital investment necessary to nuture the value added service industry.

Finally, we believe the long-term key to developing space remote sensing is, in fact, international competition and cooperation. Hence, we see the simultaneous operation of the Landsat, SPOT and other programs as desirable and inevitable. In this respect, if the U.S. gets out of this business now, we submit it will not be long before an attempt will be made to get back in it. And, the overall costs of catching up will likely far exceed those of staying ahead.

Conclusion

At issue in the present debate are several interrelated factors. These include not only the costs of the Landsat system, but also the potential benefits derived therefrom by U.S. industry and all levels of government. Furthermore, the long-term benefits in the context of Earth System Science will likely be immeasurable.

Also at issue here are profound foreign policy implications, our leadership, spirit and prestige in space related activities, and our overall vision of the future. As we enter the Age of Information, replete with its demands for data about our planet's resource base on a global scale, it seems imprudent to continue any semblance of uncertainty about maintaining one of our most basic sources of the required information.

We strongly recommend that the Landsat program be continued without delay. Furthermore, we suggest the need for a renewed national commitment to the program that provides more than mere maintenance of current capability. It is imperative that we continue to identify the appropriate mix of governmental and commercial involvement in remote sensing operations and research that enhances our capabilities in this area in a fashion insuring our competitiveness and the greatest long-term service to the national interest and that of humankind.

Epilogue

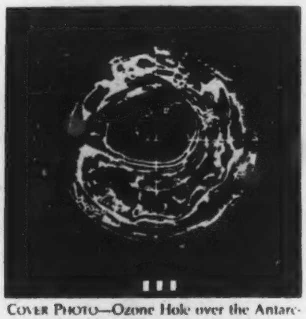
As we pointed out in our earlier House testimony in 1983..."at least historically government has had little difficulty deciding--on faith and belief in the ultimate value of science--to make substantial investments in looking at planets other than the earth, but finds it very difficult to bring itself to make even relatively modest investments in looking at the earth..." If there were ever a time to change this situation, it is now.

ATTACHMENT 1

Vol. LIII No. 1 January 1987

PE&RS

Photogrammetric Engineering & Remote Sensing



COVER PHOTO—Ozone Hole over the Antarctic. In this false color image of total atmospheric ozone over the Southern Hemisphere on October 24, 1986, the violet region near the South Pole is at the center of a distinct oval of extremely low ozone values. This region, covering almost all of Antarctica, is surrounded by a split ring of high ozone. Total ozone is measured in Dobson units (DU), equivalent to 1/1000 atm-cm; the thickness of a layer of pure ozone at NTP conditions. The color scale displays extremely low values on this day (175-200 DU) in violet and black. Blue colors represent typical subtropical amounts of 250-350 DU and the highest total ozone regions (450 DU) are shown as dark brown.

The data for this image were obtained from the Nimbus 7 Total Ozone Mapping Spectrometer (TOMS) instrument which determines ozone by measuring the albedo of the atmosphere at six ultraviolet wavelength bands between 312.5 and 380.0 nm in the edge of the Huggins absorption band. Swaths that are 2800 km wide are scanned with 50 km resolution as the spacecraft moves in a polar orbit. These swaths are merged to produce hemispheric maps of ozone each day since launch in 1978. A missing swath is illustrated by the black wedge at the left border of the figure. The image was produced with a Jupiter 7 graphics terminal and photographed with a Dunn 631 camera.

Image submitted by Arlin J. Krueger, NASA Goddard Space Flight Center, Greenbelt, Md., with the assistance of Scott Doiron and Reginald Galimore, Science Applications Research, Lanham, Md.

Photogrammetric Engineering & Remote Sensing (ISSN 0099-1112) is published monthly by the American Society for Photogrammetry and Remote Sensing, 210 Little Falls St., Falls Church, VA 22046. Second-class postage paid at Falls Church, Virginia and at additional mailing offices.

Volume LIII **January 1987** ***Number 1***

Interpretability of Advanced SPOT Film Proucts for Forest and Agricultural Survey

Color composites containing red (0.61- to 0.68-µm), photoraphic-IR (0.79- to 0.89-µm), and far-reflectance IR (2.08- to 2.35-µm) spectral bands were optimum for identifying forest and agricultural resource categories.

Stephen D. DeGloria and *Andrew S. Benson* 37

Discrimination of Altered Basaltic Rocks in the Southwestern United States by Analysis of Landsat Thematic Mapper Data

A combination of bands 1, 4, and 5 best discriminated among red cone basalts, gray flow basalts, and sedimentary rocks in three volcanic fields.

Philip A. Davis, *Graydon L. Berlin*, and *Pat S. Chavez, Jr.* 45

Terrain Analysis from Digital Patterns in Geomorphometry and Landsat MSS Spectral Response

Geomorphometric variables extracted from a digital elevation model are used to increase high relief landscape unit classification accuracy from Landsat MSS images.

Steven E. Franklin 59

Use of Topographic and Climatological Models in a Geographical Data Base to Improve Landsat MSS Classification for Olympic National Park

Topographic data and watershed boundaries (inferred precipitation/temperature) data were registered with the Landsat MSS data.

William G. Cibula and *Maurice O. Nyquist* 67

Extraction of Areas Infested by Pine Bark Beetle Using Landsat MSS Data

There was a high correlation (r = 0.824) between the timber volume of the damaged pines estimated from Landsat data and that surveyed on the ground.

Yukio Mukai, *Toshiro Sugimura*, *Hiroshi Watanabe*, and *Kuniyasu Wakamori* 77

Microcomputer-Assisted Video Image Analysis of Lodging in Winter Wheat

Lodged areas in winter wheat fields were measured from digitized aerial photos and photo interpretations to determine yield impact.

D. M. Gerten and *M. V. Wiese* 83

(Continued on page 5)

Vol LIII No 2 February 1987

PE&RS

Photogrammetric Engineering & Remote Sensing

COVER PHOTO—Baltimore's Inner Harbor, acquired by the Environmental Protection Agency (EPA) on 22 July 1982 using the EPA-Enviropod camera system. Flown at 2000 feet, the film used was EK Aerochrome 2488, with the camera set at F/5.6. Baltimore is the site of the 1987 ASPRS-ACSM Annual Convention.

The Enviropod modular-camera system incorporates two KA85A panoramic cameras, one mounted vertically, and the other pointing forward at a 45 degree angle. The Enviropod module is adapted to the Cessna 172/182 series aircraft, for which it is certified.

Photogrammetric Engineering & Remote Sensing (ISSN 0099-1112) is published monthly by the American Society for Photogrammetry and Remote Sensing, 210 Little Falls St Falls Church, VA 22046. Second-class postage paid at Falls Church, Virginia and at additional mailing offices.

Volume LIII **February 1987** **Number 2**

An FMC-Equipped Aerial Mapping Camera
Forward motion compensation is considered first in general and then with regard to the new JENA LMK Aerial Mapping Camera
Horst H. Schöler 161

Robust Estimation in Photogrammetry
It was found that these methods are by far superior to least squares in the detection and location of gross errors and outlyers
Kurt Kubik, Dean Merchant, and *Toni Schenk* 167

Application of Robust Estimation in Close-Range Photogrammetry
The bisquare estimator may be a powerful tool, but it is timeconsuming because an iteration procedure is required
S. A. Veress and *Huang Youcai* 171

The Identification of Homologous Image Points by Multiple Stereoscopic Comparison
A computer-aided control process which combines the identification of a point with its measurement in an analytical stereoplotter is described
Manfred Weisensee and *Bernhard Wrobel* 177

GLAI Estimation Using Measurements of Red, Near Infrared, and Middle Infrared Radiance
The accuracy of GLAI estimation was significantly increased by refining the methodology and not by using a middle infrared radiance index.
P. J. Curran and *H. D. Williamson* 181

Identifying Vegetable Crops with Landsat Thematic Mapper Data
Based on analysis of one season's data, TM data appear capable of providing reliable identification of vegetable crops in New York
Vicki L. Williams, Warren R. Philipson, and *William D. Philpot* 187

Forest Biomass, Canopy Structure, and Species Composition Relationships with Multipolarization L-Band Synthetic Aperture Radar Data
Multipolarization SAR backscatter is influenced by the structure of the forest vegetation, including tree heights, diameters, spacing, orientation, and geometry.
Steven A. Sader 193

(Continued on page 117)

Subscription rate for non-members is $100.00 per calendar year (add $10.00 for international subscriptions). Member subscriptions, $24.00 for regular members and $11.00 for student members, are included in the membership dues. Foreign Airmail subscription price is $165.00. U.S. First Class Mail subscription is $125.00. **POSTMASTER**: Send address changes to *PE&RS*, ASPRS Headquarters, 210 Little Falls St., Falls Church, VA 22046.

Membership in the American Society for Photogrammetry and Remote Sensing is open to any person actively engaged in the practice of Photogrammetry, Photointerpretation, and Remote Sensing, or who by means of education or profession is interested in the application or development of these arts and sciences. The annual dues for Regular members are $45.00. Annual dues for accredited Student members are $18.00. Add $10.00 for all international memberships to cover cost of postage. (All memberships are on a calendar year basis.)

Printed in the United States of America

Copyright 1987 by the American Society for Photogrammetry and Remote Sensing. Reproduction of this issue or any part thereof (except short quotations for use in preparation of technical and scientific papers) may be made only after obtaining the specific approval of the Editor. The Society is not responsible for any statements made or opinions expressed in technical papers, advertisements, or other portions of this publication.

PERMISSION TO PHOTOCOPY

The appearance of the code at the bottom of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal or internal use or for the personal or internal use of specific clients. This consent is given on the condition, however, that the copier pay the stated per copy fee of $2.25 through the Copyright Clearance Center, Inc., 21 Congress Street, Salem, MA 01970, for copying beyond that permitted by Sections 107 or 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale.

(Continued from page 115)

A Comparison of Optical Bar, High-Altitude, and Black-and-White Photography in Land Classification
High-altitude and optical bar photography were slightly more precise than black-and-white photography, but optical bar photography was the least cost effective.
Charles T. Scott, Hans T. Schreuder, and *Douglas M. Griffith* 203

Society Affairs

Officers of the Society 121
Sustaining Members 125, 127
Extraction of Information from Remotely Sensed Images 165
Color Aerial Photography in the Plant Sciences 169
ASPRS Jewelry 175
Photogrammetric Society, London 179
New Sustaining Member, *Gould Inc., Imaging & Graphics Division* 180
New Sustaining Member, *Geotech Energy Corp.* 180
Survey of the Profession 248

Journal Affairs

Permission to Photocopy 117
Index to Advertisers 123
Journal Staff 123
What *Photogrammetric Engineering and Remote Sensing* is 123
Instructions to Authors 192
Forthcoming Articles 206

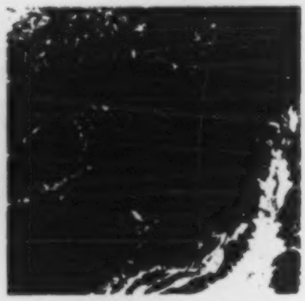
Announcements

Geographic Information Systems Conference and Workshops, San Francisco 186
Call for Papers: International Conference and Workshop on Analytical Instrumentation 191
Publications Available 202
Guidelines for Procurement of Photogrammetric Services from Private Professional Sources 207
1987 Annual Convention Preliminary Program 213
1987 Convention Exhibition Preview 228
Newsletter 233
Engineering Reports 238
Calendar 241
Professional Placement 243
Notice of Meeting: Transfer of Assets from ASP to ASPRS 245
Personality: Constance Babington Smith 246
ASPRS Store 249
ASPRS Membership Application 252

NOTICE: Correspondence relating to all business and editorial matters pertaining to this and other Society publications should be directed to the American Society for Photogrammetry and Remote Sensing, 210 Little Falls Street, Falls Church, VA 22046, including inquiries, memberships, subscriptions, changes in address, manuscripts for publication, advertising, back issues, and the MANUALS OF PHOTOGRAMMETRY AND REMOTE SENSING. The telephone number of the Society Headquarters is (703) 534-6617.

PE&RS
Photogrammetric Engineering & Remote Sensing

Volume LIII March 1987 Number 3



COVER PHOTO—Color-infrared photograph of the Andean highlands in Argentina near the Chilean border. This enlarged portion of the original photo covers an area of 8,125 square miles, and was taken by the Large Format Camera during STS Mission 41-G on 10 October 1984, using Kodak SO-131 color-infrared film. Ground resolution is approximately 20 m.

The white, snow-capped peaks of Oliva Range lie on the border between Chile and Argentina. Dark sediments have been deposited on the eastward slopes. The Tigre mountains are a series of paralleling longitudinal ranges formed by tectonic compression. Between the two ranges is the canyon of the Rio Branco, which forms a deep scar on the landscape. Flowing south, the river passes through the towns of Augualasto and Rodeo, where it turns east and continues its journey through the town of San Jose de Jarcal. The red signature of cultivated land defines large, isolated pockets of vineyards that thrive in the cool, arid climate of this major wine-producing region. A highway runs northeast from San Jose, through a large valley containing the Rio Bermejo, to the small hamlet of Chika.

The Argentine 1:100,000 map series of the region was compiled in the 1940s, but none were completed for the area contained in this LFC scene. The 1:500,000 map produced by the Instituto Geografico Militar in 1951 shows San Jose as a tiny hamlet, formerly named Jarcal. The road to Chilca had not yet been built and, from the map, cultivation along the Rio Branco is not apparent.

In October 1986, Autometric, Inc. received a Phase II contract from NASA to develop commercial applications for the LFC. This project represents another landmark in the company's history. This year, as Autometric moves forward into its fourth decade in the remote sensing business, the company will accommodate its vigorous growth by moving into a new corporate headquarters building in Springfield, Virginia.

Merging Multiresolution SPOT HRV and Landsat TM Data
Striking improvements in the quality of SPOT-1 and Landsat-5 TM multispectral images of 20-m and 28.5-m pixel resolution can be realized by using an IHS algorithm to merge the individual multispectral bands with a SPOT-1 panchromatic reference image of 10-m resolution.
R. Welch and *Manfred Ehlers* 301

The Denali Image Map
Extreme relief (over 5000 metres), short cloud-prone imaging seasons, and the stark contrast exhibited by this area presented a severe challenge to the mapmaker.
Douglas R. Binnie and *Alden P. Colvocoresses* 307

Aerotriangulation without Ground Control
Every exposure station, when equipped with an onboard GPS receiver, becomes a control point.
James R. Lucas 311

Measurements on Digitized Hardcopy Images
To maintain the precision of the original photography, the photography must be digitized at a pixel size of 10 μm or less.
J. C. Trinder 315

Determination of Optimum Sampling Interval in Grid Digital Elevation Models (DEM) Data Acquisition
The required accuracy for interpolation is the key factor in determining the optimum sampling interval.
A. E. Balce 323

Three-Dimensional Reconstruction from Two-Point Perspective Imagery
Graphical methods to provide object space dimensions from a single, unformatted, close-range image, where the only knowns may be dimensions on or near the object of concern, are discussed.
James R. Williamson and *Michael H. Brill* 331

Forum, *On Defining Remote Sensing*..............................305

(Continued on page 257)

SUBJECT INDEX

A

Aerial Photography
Precision of Stereoscopic Height Measurements, J.C. Trinder, AP1 Jan 86 75

Remote Sensing Inland Wetlands: A Multispectral Approach, John R. Jensen, Michael E. Hodgson, Eric Christensen, Halkard E. Mackey, Jr., Larry R. Tinney, and Rebecca Sharitz, AP1 Jan 86 87

Large Scale Sampling Photography for Forest Habitat Type Identification, Wm. Befort, AP1 Jan 86 101

Remote Sensing Image/Map Position Locator, Joseph J. Ullman, AP2 Feb 86 197

Seasonal Consistency of Salt Marsh Vegetation Classes Classified from Large-Scale Color Infrared Aerial Photographs, P.E.R. Dale, K. Hulsman and A.L. Chandica, AP2 Feb 86 243

Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland, John G. Lyon, Jack F. McCarthy and Joel T. Heinen, AP3 Mar 86 373

Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values, Thomas D. Frank and Scott A. Isard, AP3 Mar 86 381

Evaluation of the Effects of Photo Measurement Errors on Predictions of Stand Volume from Aerial Photography, James L. Smith, AP3 Mar 86 401

Practical Photogrammetry from 35-mm Aerial Photography, Arthur Roberts and Lori Griswold, AP4 Apr 86 501

Predicting Tree Groundline Diameter from Crown Measurements Made on 35-mm Aerial Photography, Gary F. Hagan and James L. Smith, AP5 May 86 687

The Evolving Alaska Mapping Program, Paul D. Brooks and Thomas J. O'Brien, AP6 Jun 86 769

Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell, Alaska, Carl S. Benson and Anthony B. Follett, AP6 Jun 86 813

Determining True and Magnetic North on Aerial Photographs, Frederic R. Larson, David A. Herman and Kenneth C. Winterberger, AP6 Jun 86 829

35-mm Photography: An Inexpensive Remote Sensing Tool, Richard V. Shafer and Sue A. Degler, AP6 Jun 86 833

Aerial Verification of Polygonal Resource Maps: A Low Cost Approach to Accuracy Assessment, Thomas H. George, AP6 Jun 86 839

Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000-Scale Image Mapping, Pat S. Chavez, Jr., AP10 Oct 86 1637

An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation, F.J. Ahern, W.J. Bennett and E.G. Kettela, AP10 Oct 86 1647

Cessna Aircraft Cabin Door Mount for Photographic and Videographic Cameras, Daniel S. Long, John E. Taylor and Jack McCarthy, AP11 Nov 86 1753

Accuracy of Population Estimation from Medium Scale Aerial Photography, C.P. Lo, AP12 Dec 86 1859

Agricultural Crops
Use of Multitemporal Spectral Profiles in Agricultural Land-Cover Classification, Thomas H.C. Lo, Frank L. Scarpace and Thomas M. Lillesand, AP4 Apr 86 535

Spectral Reflectance Patterns of Flooded Rice, R.D. Martin, Jr. and J.L. Heilman, AP12 Dec 86 1885

Airborne Multispectral Scanners
An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation, F.J. Ahern, W.J. Bennett and E.G. Kettela, AP10 Oct 86 1647

Air Pollution
Estimating Urban Vegetation Cover in Los Angeles, David E. Brown and Arthur M. Winer, AP1 Jan 86 117

Alaska
The Evolving Alaska Mapping Program, Paul D. Brooks and Thomas J. O'Brien, AP6 Jun 86 769

Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data, Mark Shasby and David Carneggie, AP6 Jun 86 779

Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data, Stephen S. Talbot and Carl J. Markon, AP6 Jun 86 791

Enhancing Landsat Data Acquired Under Very Low Illumination, John M. Miller and Great J. Burger, AP6 Jun 86 801

Comparison of Leaf and Canopy Reflectance of Subarctic Forests, Kenneson G. Dean, Yuji Kodama and Gerd Wendler, AP6 Jun 86 809

Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell, Alaska, Carl S. Benson and Anthony B. Follett, AP6 Jun 86 813

35-mm Photography: An Inexpensive Remote Sensing Tool, Richard V. Shafer and Sue A. Degler, AP6 Jun 86 833

Aerial Verification of Polygonal Resource Maps: A Low-Cost Approach to Accuracy Assessment, Thomas H. George, AP6 Jun 86 839

Algorithms
Radarclinometry for the Venus Radar Mapper, Robert L. Wildey, AP1 Jan 86 41

The Enhancement of Computer Classifications by Logical Smoothing, Frederick E. Townsend, AP2 Feb 86 213

Orthographic Terrain Views Using Data Derived from Digital Elevation Models, Ralph O. Dubayah and Jeff Dozier, AP4 Apr 86 509

Processing Techniques for Digital Sonar Images from GLORIA, Pat S. Chavez, Jr., AP8 Aug 86 1133

A Class of Algorithms for Enumerating Rare Objects Using Spectral and Spatial Data in Real Time, David R. Anderson, Clair L. Wyatt, Mohan M. Trivedi and Roger K. Harshbarger, AP8 Aug 86 1158

Advanced Very High Resolution Radiometer
Utility of AVHRR Channels 3 and 4 in Land-Cover Mapping, A.G. Kerber and J.B. Schutt, AP12 Dec 86 1877

Antenna Measurements
Microwave Antenna Measurement by Photogrammetry, Clive S. Fraser, AP10 Oct 86 1627

Array Cameras
Calibration of an Array Camera, Sean Curry, Sheldon Baumrind and J.M. Anderson, AP5 May 86 627

(ASPRS) ACSM/ASPRS Annual Convention
1986 Meeting Report: New Horizons, Firm Foundations, AP7 Jul 86 931

(ASPRS) Alan Gordon Memorial Award
The Alan Gordon Memorial Award, AP7 Jul 86 958

(ASPRS) Autometric Award
The Autometric Award, AP7 Jul 86 956

(ASPRS) Awards Policy Committee
Annual Report, AP7 Jul 86 1000

(ASPRS) A Word with the Executive Director
Racing Into Tomorrow, William D. French, AP1 Jan 86 142

(ASPRS) Bausch and Lomb Award
The Bausch and Lomb Photogrammetric Award, AP7 Jul 86 956

(ASPRS) Birdseye President's Citation
Col. Claude H. Birdseye President's Citation, AP7 Jul 86 968

(ASPRS) Certification Program
ASPRS Voluntary Certification Program, List of Certified Photogrammetrists, AP7 Jul 86 1015

Evaluation for Certification Committee, Annual Report, Abraham Anson, AP7 Jul 86 1019

(ASPRS) Close-Range Committee, Photogrammetric Applications Division
Annual Report, S.A. Veress, AP7 Jul 86 1000

(ASPRS) Constitution and Bylaws Committee
Annual Report, Alan W. Voss, AP7 Jul 86 1001

(ASPRS) Education Committee
Annual Report, Ralph W. Kiefer, AP7 Jul 86 1004

(ASPRS) Executive Director's Report
Report by William D. French, AP7 Jul 86 991

(ASPRS) Ford Bartlett Award
The Ford Bartlett Award, AP7 Jul 86 960

(ASPRS) Geographic Information Management Systems Committee
Annual Report, Terry Keating and Billie Swenson, AP7 Jul 86 998

(ASPRS) Honorary Membership
The Honorary Membership Award, Claude H. Birdseye (posthumos), Revere G. Sanders, William A. Radlinski, AP7 Jul 86 943

(ASPRS) Installation of Officers and Awards Meeting
52nd, AP7 Jul 86 941

(ASPRS) Interviews
Vincent V. Salomonson, by Don Hemenway, AP2 Feb 86 288

Al Stevens, by Don Hemenway, AP5 May 86 707

(ASPRS) Joint ASPRS/ACSM Program Planning Committee
Report on Conflicts Between Business Meetings and Technical Sessions, AP7 Jul 86 1010

(ASPRS) Joint Convention Task Force
Annual Report, AP7 Jul 86 1011

(ASPRS) Joint Education Program
Annual Report, Marshall W. Davies, AP7 Jul 86 1005

(ASPRS) Joint Government Affairs Committee
Annual Report, Tom O. McCullough, AP7 Jul 86 1008

(ASPRS) Joint Members in Government Committee
Annual Report, Steven J. Vogel, AP7 Jul 86 1001

(ASPRS) Joint Program Planning Committee
Annual Report, Alberta Auringer Wood, AP7 Jul 86 1003

(ASPRS) Keynote Address
Frank Press, AP7 Jul 86 937

(ASPRS) Long Range Planning Goals
AP7 Jul 86 1020

(ASPRS) Luis Struck Award
The Luis Struck Award, AP7 Jul 86 957

(ASPRS) Memorial Address: Virgil Kauffman
Homer Jensen and C. Eric Storms. AP7 Jul 86 973

(ASPRS) Memorial Address: William C. Cude
Eldon D. Sewell, AP7 Jul 86 983

(ASPRS) Members Emeritus
List of Members Emeritus. AP7 Jul 86 970

(ASPRS) Newsletter of the Year
Newsletter of the Year Award. AP7 Jul 86 965

(ASPRS) Photogrammetric Applications Division
Annual Report. Ronald K. Brewer. AP7 Jul 86 997

(ASPRS) Photogrammetric Award
The Photogrammetric (Fairchild) Award. AP7 Jul 86 962

(ASPRS) Presidential Citations for Meritorious Service
1986 Presidential Recipients. AP7 Jul 86 967

(ASPRS) President's Award for Practical Papers
AP7 Jul 86 966

(ASPRS) President's Report
Report by Tamein G. Barnes. AP7 Jul 86 989

(ASPRS) President's Inaugural Address
Alan R. Stevens. AP7 Jul 86 992

(ASPRS) Primary Data Acquisition Division
Annual Report. E. Fleming. AP7 Jul 86 996

(ASPRS) Proposed Guidelines for Procurement of Photogrammetric Services from Private Sources
Draft. George F. Walker. AP7 Jul 86 1023

(ASPRS) Publications Committee
Annual Report. Lawrence W. Fritz. AP7 Jul 86 1002

(ASPRS) Region of the Year
Region of the Year Award. AP7 Jul 86 962

(ASPRS) Region Presidents and Directors
Meeting Report. Kim Williams. AP7 Jul 86 993

(ASPRS) Robert E. Altenhofen Scholarship
The Robert E. Altenhofen Memorial Scholarship. AP7 Jul 86 961

(ASPRS) Survey of the Profession Committee
Annual Report. Anthony B. Follett. AP7 Jul 86 1001

(ASPRS) Talbert Abrams Award
The V. Talbert Abrams Award. AP7 Jul 86 954

(ASPRS) Wild Heerbrugg Award
The Wild Heerbrugg Photogrammetric Fellowship Award. AP7 Jul 86 959

(ASPRS) William A. Fischer Scholarship
The William A. Fischer Memorial Scholarship. AP7 Jul 86 960

ASTRA Mapping System
ASTRA—A System for Automated Scale Transition. F.W. Leberl, D. Olson and W. Lichtner. AP2 Feb 86 251

Atmospheric Optics
Absolute Calibration of Field Reflectance Radiometers. Ray D. Jackson and Philip N. Slater. AP2 Feb 86 189

Australia
Use of SIR-A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore, South Australia. Glen M. Green. AP5 May 86 659

Automatic Correlation
Capturing Facial Surface Information. Michael Keefe and Donald R. Riley. AP9 Sep 86 1539

Automatic Measurements
Real-Time Image Metrology with CCD Cameras. S.F. El-Hakim. AP11 Nov 86 1757

B

Background Reflectance
Sun Angle, View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies. K.J. Ranson, C.S.T. Daughtry and L.L. Biehl. AP5 May 86 649

Canopy Reflectance of Two Drought-Stressed Shrubs. J.H. Everitt and P.R. Nixon. AP8 Aug 86 1189

Band Ratio Response
Response of Some Thematic Mapper Band Ratios to Variation in Soil Water Content. E. Brad Musick and Ramona E. Pelletier. AP10 Oct 86 1661

Band Selection
Issues Arising from Sampling Designs and Band Selection in Discriminating Ground Reference Attributes Using Remotely Sensed Data. M.L. Labovitz. AP2 Feb 86 201

Bibliographies
Education in Environmental Remote Sensing: A Bibliography and Characterization of Doctoral Dissertations. Robert W. Merideth, Jr. and Arthur B. Sacks. AP3 Mar 86 349

Biostereometric Data
Calibration of an Array Camera. Sean Curry, Sheldon Baumrind and J.M. Anderson. AP5 May 86 627

Capturing Facial Surface Information. Michael Keefe and Donald R. Riley. AP9 Sep 86 1539

Book Review
Atlas of North America: Space Age Portrait of a Continent. Wilbur E. Garrett, Editor. Reviewed by Benjamin F. Richason, Jr. AP6 Jun 86 787

Photometry and Polarization in Remote Sensing. Walter G. Egan. AP6 Jun 86 789

Optical Remote Sensing of Air Pollution. P. Camagni and S. Sandroni, Editors. Reviewed by William B. Grant. AP6 Jun 86 789

The Joint NASA/GEOSAT Test Case Project Final Report. Michael J. Abrams, James E. Conel, Harold J. Lang and Helen N. Paley, Editors. Reviewed by Robert G. Reeves. AP11 Nov 86 1775

Techniques for Image Processing and Classification in Remote Sensing. Robert A. Schowengerdt. Reviewed by Brian Markham. AP11 Nov 86 1776

Biostereometrics 85: SPIE Proceedings Vol. 602 of a Conference Held in Cannes, France, 3-6 December 1985. A.M. Coblentz, Editor. Reviewed by H.M. Karara. AP11 Nov 86 1777

Bundle Adjustment
Calibration of an Array Camera. Sean Curry, Sheldon Baumrind and J.M. Anderson. AP5 May 86 627

System Calibration and Self Calibration. Part I: Rotationally Symmetrical Lens Distortion and Image Deformation. Hartmut Ziemann and Sabry F. El-Hakim. AP10 Oct 86 1617

C

Calibration
Lens Distortion for Close-Range Photogrammetry. John G. Fryer and Duane C. Brown. AP1 Jan 86 51

Absolute Calibration of Field Reflectance Radiometers. Ray D. Jackson and Philip N. Slater. AP2 Feb 86 189

Self Calibration Using the Finite Element Approach. Raadh A. Hakim Muniy. AP3 Mar 86 411

Calibration of an Array Camera. Sean Curry, Sheldon Baumrind and J.M. Anderson. AP5 May 86 627

Calibrating Non-Metric Cameras Using the Finite Element Method. Raadh A. Hakim Muniy. AP8 Aug 86 1201

System Calibration and Self Calibration. Part I: Rotationally Symmetrical Lens Distortion and Image Deformation. Hartmut Ziemann and Sabry F. El-Hakim. AP10 Oct 86 1617

Camera Mounts
Cessna Aircraft Cabin Door Mount for Photographic and Videographic Cameras. Daniel S. Long, John E. Taylor and Jack McCarthy. AP11 Nov 86 1753

Canopy Reflectance
Comparison of Leaf and Canopy Reflectance of Subarctic Forests. Kenneson G. Dean, Yuji Kodama and Gerd Wendler. AP6 Jun 86 809

Canopy Reflectance of Two Drought-Stressed Shrubs. J.H. Everitt and P.R. Nixon. AP8 Aug 86 1181

Canopy Reflectance Characteristics of Succulent and Nonsucculent Rangeland Plant Species. J.H. Everitt, A.J. Richardson and P.R. Nixon. AP12 Dec 86 1891

Carbon Black Aggregate
Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System. M.S. Elghazali. AP11 Nov 86 1767

Cartography
A Robust Solution to the Line-Matching Problem in Photogrammetry and Cartography. Tony Schenk. AP11 Nov 86 1779

Cessna Aircraft
Cessna Aircraft Cabin Door Mount for Photographic and Videographic Cameras. Daniel S. Long, John E. Taylor and Jack McCarthy. AP11 Nov 86 1753

Change Detection
Economical Maintenance of a National Topographic Data Base Using Landsat Images. Alan F. Gregory and Harold D. Moore. AP4 Apr 86 519

Charge-Coupled Device Cameras
Real-Time Image Metrology with CCD Cameras. S.F. El-Hakim. AP11 Nov 86 1757

Chromaticity Technique
A Further Development of the Chromaticity Technique for Satellite Mapping of Suspended Sediment Load. Tommy Lindell, Bert Karlsson, Mats Rosengren and Tom Alföldi. AP9 Sep 86 1521

Classification
Large Scale Sampling Photography for Forest Habitat Type Identification. Wm. Befort. AP1 Jan 86 101

The Enhancement of Computer Classifications by Logical Smoothing. Frederick E. Townsend. AP2 Feb 86 213

Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data. Stephen S. Talbot and Carl J. Markon. AP6 Jun 86 791

Spatial Diversity Index Mapping of Classes in Grid Cell Maps. Charles J. Robinove. AP8 Aug 86 1171

Identification of Two Southern Pine Species in High Resolution Aerial MSS Data. J.S. Hughes, D.L. Evans, P.Y. Burns and J.M. Hill. AP8 Aug 86 1175

A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure. Knut Conradsen and Jan Gunulf. AP8 Aug 86 1181

Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data. Leslie A. Morrissey and Laurence L. Strong. AP9 Sep 86 1513

Accuracy of Population Estimation from Medium Scale Aerial Photography. C.P. Lo. AP12 Dec 86 1859

Utility of AVHRR Channels 3 and 4 in Land Cover Mapping. A.G. Kerber and J.B. Schutt. AP12 Dec 86 1877

Classification Accuracy
Issues Arising from Sampling Designs and Band Selection in Discriminating Ground Reference Attributes Using Remotely Sensed Data. M.L. Labovitz. AP2 Feb 86 201

A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. George H. Rosenfield and Katherine Fitzpatrick-Lins. AP2 Feb 86 223

The Utility of Thematic Mapper Sensor Characteristics for Surface Mine Monitoring. James R. Irons and Ruth L. Kennard. AP3 Mar 86 389

Accuracy Assessment: A User's Perspective. Michael Story and Russell G. Congalton. AP3 Mar 86 397

Analysis of Thematic Map Classification Error Matrices. George H. Rosenfield. AP5 May 86 681

An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr. AP8 Aug 86 1146

Classification Strategies
Use of Multitemporal Spectral Profiles in Agricultural Land-Cover Classification. Thomas H.C. Lo, Frank L. Scarpace and Thomas M. Lillesand. AP4 Apr 86 535

A Class of Algorithms for Enumerating Rare Objects Using Spectral and Spatial Data in Real Time. David R. Anderson, Clair L. Wyatt, Mohan M. Trivedi and Roger K. Harshbarger. AP8 Aug 86 1158

Class Signature Analysis
Utility of AVHRR Channels 3 and 4 in Land-Cover Mapping. A.G. Kerber and J.B. Schutt. AP12 Dec 86 1877

Close-Range Mapping
Close-Range Mapping with a Solid State Camera. Kam W. Wong and Sei-Hsin Ho. AP1 Jan 86 67

Close-Range Photogrammetry
Lens Distortion for Close-Range Photogrammetry. John G. Fryer and Duane C. Brown. AP1 Jan 86 51

Parallelism of the Stereometric Camera Base to the Datum Plane in Close-Range Photogrammetry. Oguz Mutluoglu. AP8 Aug 86 1207

Microwave Antenna Measurement by Photogrammetry. Clive S. Fraser. AP10 Oct 86 1627

Coastal Zones
An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr. AP8 Aug 86 1146

Coefficient of Agreement
A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. George H. Rosenfield and Katherine Fitzpatrick-Lins. AP2 Feb 86 223

Color Infrared Photography
Semi-Automatic Survey of Crop Damage Using Color Infrared Photography. G. Ladouceur, R. Allard and S. Ghosh. AP1 Jan 86 111

Estimating Urban Vegetation Cover in Los Angeles. David E. Brown and Arthur M. Winer. AP1 Jan 86 117

Seasonal Consistency of Salt Marsh Vegetation Classes Classified from Large-Scale Color Infrared Aerial Photographs. P.E.R. Dale, K. Hulsman and A.L. Chandica. AP2 Feb 86 243

Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values. Thomas D. Frank and Scott A. Isard. AP3 Mar 86 381

Computer Graphics
Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland. John G. Lyon, Jack F. McCarthy and Joel T. Heinen. AP3 Mar 86 373

Computer Programs
Determining True and Magnetic North on Aerial Photographs. Frederic R. Larson, David A. Herman and Kenneth C. Winterberger. AP6 Jun 86 829

Computer Software
The Digital Image Analysis System (DIAS): Microcomputer Software for Remote Sensing Education. John A. Harrington, Jr., Kevin F. Cartin, and Ray Lougeay. AP4 Apr 86 545

Processing Techniques for Digital Sonar Images from GLORIA. Pat S. Chavez, Jr. AP8 Aug 86 1133

A Robust Solution to the Line-Matching Problem in Photogrammetry and Cartography. Tony Schenk. AP11 Nov 86 1779

Control Points
Close-Range Mapping with a Solid State Camera. Kam W. Wong and Wei-Hsin Ho. AP1 Jan 86 67

Satellite Orientation and Position for Geometric Correction of Scanner Imagery. Paul H. Salamonowicz. AP4 Apr 86 491

Coordinate Measurements
Real-Time Image Metrology with CCD Cameras. S.F. El-Hakim. AP11 Nov 86 1757

Co-Registered Imagery
Orthographic Terrain Views Using Data Derived from Digital Elevation Models. Ralph O. Dubayah and Jeff Dozier. AP4 Apr 86 509

Crop Damage Surveys
Semi-Automatic Survey of Crop Damage Using Color Infrared Photography. G. Ladouceur, R. Allard and S. Ghosh. AP1 Jan 86 111

Crop Growth
Spectral Reflectance Patterns of Flooded Rice. R.D. Martin, Jr. and J.L. Heilman. AP12 Dec 86 1885

Crown Measurements
Predicting Tree Groundline Diameter from Crown Measurements Made on 35-mm Aerial Photography. Gary F. Hagan and James L. Smith. AP5 May 86 687

D

Data Adjustment
The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data. S.F. El-Hakim. AP1 Jan 86 59

Satellite Orientation and Position for Geometric Correction of Scanner Imagery. Paul H. Salamonowicz. AP4 Apr 86 491

Processing Techniques for Digital Sonar Images from GLORIA. Pat S. Chavez, Jr. AP8 Aug 86 1133

Data Analysis
The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data. S.F. El-Hakim. AP1 Jan 86 59

Semi-Automatic Survey of Crop Damage Using Color Infrared Photography. G. Ladouceur, R. Allard and S. Ghosh. AP1 Jan 86 111

Issues Arising from Sampling Designs and Band Selection in Discriminating Ground Reference Attributes Using Remotely Sensed Data. M.L. Labovitz. AP2 Feb 86 201

Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan. Richard G. Lathrop, Jr. and Thomas M. Lillesand. AP5 May 86 671

A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure. Knut Conradsen and Jan Gunulf. AP8 Aug 86 1181

Performance Evaluation of Two Bivariate Processes for DEM Data Using Transfer Functions. Mohamed Shawki Elghazali and Mohsen Mostafa Hassan. AP8 Aug 86 1213

Canopy Reflectance Characteristics of Succulent and Nonsucculent Rangeland Plant Species. J.H. Everitt, A.J. Richardson and P.R. Nixon. AP12 Dec 86 1891

Data Base Systems
Applications of Landsat Data and the Data Base Approach. Donald T. Lauer. AP8 Aug 86 1193

Data Correlation
Close-Range Mapping with a Solid State Camera. Kam W. Wong and Wei-Hsin Ho. AP1 Jan 86 67

The Importance of Measurement Error for Certain Procedures in Remote Sensing at Optical Wavelengths. Paul J. Curran and Alan M. Hay. AP2 Feb 86 229

Data Encoding
Generating False-Color Composites with a White-Light Optical Processor. F.T.S. Yu and G.W. Peterson. AP3 Mar 86 367

Data Management
Mass Storage Estimates for the Digital Mapping Era. Donald L. Light. AP3 Mar 86 419

Data Merging
Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000-Scale Image Mapping. Pat S. Chavez, Jr. AP10 Oct 86 1637

Data Processing
Problem-Solving with Remote Sensing: An Update. Warren R. Philipson. AP1 Jan 86 109

Semi-Automatic Survey of Crop Damage Using Color Infrared Photography. G. Ladouceur, R. Allard and S. Ghosh. AP1 Jan 86 111

The Enhancement of Computer Classifications by Logical Smoothing. Frederick E. Townsend. AP2 Feb 86 213

The Digital Image Analysis System (DIAS): Microcomputer Software for Remote Sensing Education. John A. Harrington, Jr., Kevin F. Cartin and Ray Lougeay. AP4 Apr 86 545

Data Structures
The Tasseled Cap De-Mystified. E.P. Crist and R.J. Kauth. AP1 Jan 86 81

Data Transformations
The Tasseled Cap De-Mystified. E.P. Crist and R.J. Kauth. AP1 Jan 86 81

Datum Plane Rotation
Parallelism of the Stereometric Camera Base to the Datum Plane in Close-Range Photogrammetry. Oguz Mutluoglu. AP8 Aug 86 1207

Decentering Distortion
Lens Distortion for Close-Range Photogrammetry. John G. Fryer and Duane C. Brown. AP1 Jan 86 51

Defoliation Surveys
An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation. F.J. Ahern, W.J. Bennett and E.G. Kettela. AP10 Oct 86 1647

Densitometry
Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values. Thomas D. Frank and Scott A. Isard. AP3 Mar 86 381

Digital Cross-Sections
Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell, Alaska. Carl S. Benson and Anthony B. Follett. AP6 Jun 86 813

Digital Data Base
Applications of Landsat Data and the Data Base Approach. Donald T. Lauer. AP8 Aug 86 1193

Capturing Facial Surface Information. Michael Keefe and Donald R. Riley. AP9 Sep 86 1539

Digital Elevation Models
Orthographic Terrain Views Using Data Derived from Digital Elevation Models. Ralph O. Dubayah and Jeff Dozier. AP4 Apr 86 509

Performance Evaluation of Two Bivariate Processes for DEM Data Using Transfer Functions. Mohamed Shawki Elghazali and Mohsen Mostafa Hassan. AP8 Aug 86 1213

Digital Image Analysis System (DIAS)
The Digital Image Analysis System (DIAS): Microcomputer Software for Remote Sensing Education. John A. Harrington, Jr., Kevin F. Cartin and Ray Lougeay. AP4 Apr 86 545

Digital Imagery
Close-Range Mapping with a Solid State Camera. Kam W. Wong and Wei-Hsin Ho. AP1 Jan 86 67

Processing Techniques for Digital Sonar Images from GLORIA. Pat S. Chavez, Jr., AP8 Aug 86 1133

An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr., AP8 Aug 86 1146

Opposite-Side SAR Image Processing for Stereo Viewing. J. Kevin Fullerton, Franz Leberl and Robert E. Marque. AP9 Sep 86 1487

Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000-Scale Image Mapping. Pat S. Chavez, Jr., AP10 Oct 86 1637

An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation. F. J. Ahern, W. J. Bennett and E. G. Kettela. AP10 Oct 86 1647

A Robust Solution to the Line-Matching Problem in Photogrammetry and Cartography. Tony Schenk, AP11 Nov 86 1779

Digital Mapping
Close Range Mapping with a Solid State Camera. Kam W. Wong and Wei-Hsin Ho, AP1 Jan 86 67

ASTRA—A System for Automated Scale Transition. F. W. Leberl, D. Olson and W. Lichtner, AP2 Feb 86 251

Mass Storage Estimates for the Digital Mapping Era. Donald L. Light. AP3 Mar 86 419

Planning for Optical Disk Technology with Digital Cartography. Donald L. Light. AP4 Apr 86 551

Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan. Richard G. Lathrop, Jr. and Thomas M. Lillesand. AP5 May 86 671

The Evolving Alaska Mapping Program. Paul D. Brooks and Thomas J. O'Brien. AP6 Jun 86 769

Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data. Stephen S. Talbot and Carl J. Markon. AP6 Jun 86 791

Digital Mass Storage
Mass Storage Estimates for the Digital Mapping Era. Donald L. Light. AP3 Mar 86 419

Planning for Optical Disk Technology with Digital Cartography. Donald L. Light. AP4 Apr 86 551

Digital Terrain Data
Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data. Mark Shasby and David Carneggie. AP6 Jun 86 779

Digital Terrain Models
Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System. M. S. Elghazali. AP11 Nov 86 1767

Direct Linear Transformation
Capturing Facial Surface Information. Michael Keefe and Donald R. Riley. AP9 Sep 86 1539

Doctoral Dissertations
Education in Environmental Remote Sensing: A Bibliography and Characterization of Doctoral Dissertations. Robert W. Merideth, Jr. and Arthus B. Sacks. AP3 Mar 86 349

Drought Stress
Canopy Reflectance of Two Drought Stressed Shrubs. J. H. Everitt and P. R. Nixon. AP8 Aug 86 1189

Dwelling Unit Count Method
Accuracy of Population Estimation from Medium Scale Aerial Photography. C. P. Lo. AP12 Dec 86 1859

E

Education
Education in Environmental Remote Sensing: A Bibliography and Characterization of Doctoral Dissertations. Robert W. Merideth, Jr. and Arthur B. Sacks. AP3 Mar 86 349

The Digital Image Analysis System (DIAS): Microcomputer Software for Remote Sensing Education. John A. Harrington, Jr., Kevin F. Cartin and Ray Lougeay. AP 4 Apr 86 545

Edge Distortion
Fourier Transform Techniques for the Evaluation of the Thematic Mapper Line Spread Function. Walter H. Carnahan and Guoping Zhou. AP5 May 86 639

Environmental Studies
Remote Sensing Inland Wetlands: A Multispectral Approach. John R. Jensen, Michael E. Hodgson, Eric Christensen, Halkard E. Mackey, Jr., Larry R. Tinney and Rececca Sharitz, AP1 Jan 86 87

Large Scale Sampling Photography for Forest Habitat-Type Identification. Wm. Befort. AP1 Jan 86 101

Education in Environmental Remote Sensing: A Bibliography and Characterization of Doctoral Dissertations. Robert W. Merideth, Jr. and Arthur B. Sacks. AP3 Mar 86 349

Generating False-Color Composites with a White-Light Optical Processor. F. T. S. Yu and G. W. Petersen. AP3 Mar 86 367

35-mm Photography: An Inexpensive Remote Sensing Tool. Richard V. Shafer and Sue A. Degler. AP6 Jun 86 833

Error Detection
The Detection of Gross and Systematic Errors in the Combined Ajustment of Terrestrial and Photogrammetric Data. S. F. El-Hakim. AP1 Jan 86 59

Error Matrices
A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. George H. Rosenfield and Katherine Fitzpatrick-Lins. AP2 Feb 86 223

Accuracy Assessment: A User's Perspective. Michael Story and Russel G. Congalton. AP3 Mar 86 397

Analysis of Thematic Map Classification Error Matrices. George H. Rosenfield. AP5 May 86 681

Escoding
ASTRA—A System for Automated Scale Transition. F. W. Leberl, D. Olson and W. Lichtner. AP2 Feb 86 251

Estimation Error
Accuracy of Population Estimation from Medium Scale Aerial Photography. C. P. Lo, AP12 Dec 86 1859

Exoatmospheric Irradiance
Absolute Calibration of Field Reflectance Radiometers. Ray D. Jackson and Philip N. Slater. AP2 Feb 86 189

F

Facial Surface Information
Capturing Facial Surface Information. Micheal Keefe and Donald R. Riley. AP9 Sep 86 1539

False-Color Composites
Generating False-Color Composites with a White-Light Optical Processor. F. T. S. Yu and G. W. Petersen. AP3 Mar 86 367

Farmland
Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland. John G. Lyon, Jack F. McCarthy and Joel T. Heinen. AP3 Mar 86 373

Finite Element Analysis
Self Calibration Using the Finite Element Approach. Riadh A. Halim Munjy. AP3 Mar 86 411

Calibrating Non-Metric Cameras Using the Finite-Element Method. Riadh A. Halim Munjy. AP8 Aug 1201

Focal Plane Orientation
Parallelism of the Stereometric Camera Base to the Datum Plane in Close-Range Photogrammetry. Oguz Muftuoglu. AP8 Aug 86 1207

Focusing
Lens Distortion for Close-Range Photogrammetry. John G. Fryer and Duane C. Brown. AP1 Jan 86 51

Forest Canopies
Sun Angle, View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies. K. J. Ranson, C. S. T. Daughtry and L. L. Biehl. AP5 May 86 649

Forestry
Evaluation of the Effects of Photo Measurement Errors on Predictions of Stand Volume from Aerial Photography. James J. Smith. AP3 Mar 86 401

An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation. F. J. Ahern, W. J. Bennett and E. G. Kettela. AP10 Oct 86 1647

Forests
Large Scale Sampling Photography for Forest Habitat-Type Identification. Wm. Befort. AP1 Jan 86 101

Comparison of Leaf and Canopy Reflectance of Subarctic Forests. Kenneson G. Dean, Yuki Kodama and Gerd Wendler. AP6 Jun 86 809

Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data. Leslie A. Morrissey and Laurence L. Strong. AP9 Sep 86 1513

Forest Species
Sun Angle, View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies. K. J. Ranson, C. S. T. Daughtry and L. L. Biehl. AP5 May 86 649

Analysis of Thematic Map Classification Error Matrices. George H. Rosenfield. AP5 May 86 681

Predicting Tree Groundline Diameter from Crown Measurements Made on 35-mm Aerial Photography. Gary F. Hagan and James L. Smith. AP5 May 86 687

Identification of Two Southern Pine Species in High Resolution Aerial MSS Data. J. S. Hughes, D. L. Evans, P. Y. Burns and J. M. Hill. AP8 Aug 86 1175

An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation. F. J. Ahern, W. J. Bennett and E. G. Kettela. AP10 Oct 86 1647

Fourier Transform
Fourier Transform Techniques for the Evaluation of the Thematic Mapper Line Spread Function. Walter H. Carnahan and Guoping Zhou. AP5 May 86 639

Fruit Trees
Fruit Tree Inventory with Landsat Thematic Mapper Data. Daniel K. Gordon, Warren R. Philipson and William D. Philpot. AP12 Dec 86 1871

G

Geographic Data Base
Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data. Leslie A. Morrissey and Laurence L. Strong, AP9 Sep 86 1513

Geological Mapping
Geological Mapping Potential of Computer Enhanced Images from the Shuttle Imaging Radar: Lisbon Valley Anticline, Utah. J.D. Curlis, V.S. Frost and L.F. Dellwig, AP4 Apr 86 525

A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure. Knut Conradsen and Jan Gunulf, AP8 Aug 86 1181

Geometric Correction
Satellite Orientation and Position for Geometric Correction of Scanner Imagery. Paul H. Salamonowicz, AP4 Apr 86 491

Geometric Image
Vertical Exaggeration in Stereo-Vision: Theories and Facts, Humberto Rosas. AP11 Nov 86 1747

Glaciers
Application of Photogrammetry to the Study of Volcano Glacier Interactions on Mount Wrangell, Alaska. Carl S. Benson and Anthony B. Follett, AP6 Jun 86 813

GLORIA (Geological Long Range Inclined Asdic) System
Processing Techniques for Digital Sonar Images from GLORIA, Pat S. Chavez, Jr., AP8 Aug 86 1133

Green Bay, Wisconsin
Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan. Richard G. Lathrop, Jr. and Thomas M. Lillesand, AP5 May 86 671

Grid Cell Maps
Spatial Diversity Index Mapping of Classes in Grid Cell Maps, Charles J. Robinove, AP8 Aug 86 1171

Gross Errors
The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data. S.F. El-Hakim, AP1 Jan 86 59

Groundline Diameter Determination
Predicting Tree Groundline Diameter from Crown Measurements Made on 35-mm Aerial Photography. Gary F. Hagan and James L. Smith, AP5 May 86 687

Ground Reference
Issues Arising from Sampling Designs and Band Selection in Discriminating Ground Reference Attributes Using Remotely Sensed Data. M.L. Labovitz, AP2 Feb 86 201

The Importance of Measurement Error for Certain Procedures in Remote Sensing at Optical Wavelengths. Paul J. Curran and Alan M. Hay, AP2 Feb 86 229

H

Habitats
Large-Scale Sampling Photography for Forest Habitat-Type Identification, Wm. Befort, AP1 Jan 86 101

An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr., AP8 Aug 86 1146

Height Measurements
Precision of Stereoscopic Height Measurements. J.C. Trinder, AP1 Jan 86 75

Hierarchical Procedure
A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure. Knut Conradsen and Jan Gunulf, AP8 Aug 86 1181

Hydrocarbon Emissions
Estimating Urban Vegetation Cover in Los Angeles. David E. Brown and Arthur M. Winer, AP1 Jan 86 117

Hydrology
Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values. Thomas D. Frank and Scott A. Isard, AP3 Mar 86 381

Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover. Laurie J. Troiler and Warren R. Philipson, AP9 Sep 86 1531

I

Image Accuracy
Accuracy Assessment: A User's Perspective, Michael Story and Russell G. Congalton, AP3 Mar 86 397

Image Analysis
Estimating Urban Vegetation Cover in Los Angeles, David E. Brown and Arthur M. Winer, AP1 Jan 86 117

Processing Techniques for Digital Sonar Images from GLORIA, Pat S. Chavez, Jr., AP8 Aug 86 1133

Identification of Two Southern Pine Species in High-Resolution Aerial MSS Data, J.S. Hughes, D.L. Evans, P.Y. Burns and J.M. Hill, AP8 Aug 86 1175

Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover, Laurie J. Troiler and Warren R. Philipson, AP9 Sep 86 1531

Capturing Facial Surface Information, Michael Keefe and Donald R. Riley, AP9 Sep 86 1539

An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation, F.J. Ahern, W.J. Bennett and E.G. Kettela, AP10 Oct 86 1647

Vertical Exaggeration in Stereo-Vision: Theories and Facts, Humberto Rosas, AP11 Nov 86 1747

Real Time Image Metrology with CCD Cameras, S.F. El-Hakim, AP11 Nov 86 1757

Utility of AVHRR Channels 3 and 4 in Land-Cover Mapping, A.G. Kerber and J.B. Schutt, AP12 Dec 86 1877

Image Corrections
Practical Photogrammetry from 35-mm Aerial Photography. Paul H. Salamonowicz, AP4 Apr 86 491

Image Deformation
System Calibration and Self-Calibration. Part I. Rotationally Symmetrical Lens Distortion and Image Deformation, Hartmut Ziemann and Sabry F. El-Hakim, AP10 Oct 86 1617

Image Digitization
Calibration of an Array Camera, Sean Curry, Sheldon Baumrind and J.M. Anderson, AP5 May 86 627

Image Displacement
Parallelism of the Stereometric Camera Base to the Datum Plane in Close-Range Photogrammetry, Oguz Muftuoglu, AP8 Aug 86 1207

Image Enhancement
The Enhancement of Computer Classifications by Logical Smoothing, Frederick E. Townsend, AP2 Feb 86 213

Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland, John G. Lyon, Jack F. McCarthy and Joel T. Heinen, AP3 Mar 86 373

Geological Mapping Potential of Computer-Enhanced Images from the Shuttle Imaging Radar: Lisbon Valley Anticline, Utah, J.D. Curlis, V.S. Frost and L.F. Dellwig, AP4 Apr 86 525

Enhancing Landsat Data Acquired Under Very Low Illumination, John M. Miller and Greta J. Burger, AP6 Jun 86 801

Image Mapping
The Evolving Alaska Mapping Program, Paul D. Brooks and Thomas J. O'Brien, AP6 Jun 86 769

Image Mapping with the Thematic Mapper, Alden P. Colvocoresses, AP9 Sep 86 1499

Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000-Scale Image Mapping, Pat S. Chavez, Jr., AP10 Oct 86 1637

Image Processing
Problem-Solving with Remote Sensing: An Update, Warren R. Philipson, AP1 Jan 86 109

Satellite Orientation and Position for Geometric Correction of Scanner Imagery, Paul H. Salamonowicz, AP4 Apr 86 491

Orthographic Terrain Views Using Data Derived from Digital Elevation Models, Ralph O. Dubayah and Jeff Dozier, AP4 Apr 86 509

The Digital Image Analysis System (DIAS): Microcomputer Software for Remote Sensing Education, John A. Harrington, Jr., Kevin F. Cartin and Ray Lougeay, AP4 Apr 86 545

Calibration of an Array Camera, Sean Curry, Sheldon Baumrind and J.M. Anderson, AP5 Mary 86 627

Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data, Stephen S. Talbot and Carl J. Markon, AP6 Jun 86 791

Processing Techniques for Digital Sonar Images from GLORIA, Pat S. Chavez, Jr., AP8 Aug 86 1133

Opposite-Side SAR Image Processing for Stereo Viewing, J. Kevin Fullerton, Franz Leberl and Robert E. Marque, AP9 Sep 86 1487

Image Mapping with the Thematic Mapper, Alden P. Colvocoresses, AP9 Sep 86 1499

A Further Development of the Chromaticity Technique for Satellite Mapping of Suspended Sediment Load, Tommy Lindell, Bert Karlsson, Mats Rosengren and Tom Alföldi, AP9 Sep 86 1521

Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000-Scale Image Mapping, Pat S. Chavez, Jr., AP10 Oct 86 1637

A Robust Solution to the Line-Matching Problem in Photogrammetry and Cartography, Tony Schenk, AP11 Nov 86 1779

Image Registration
Economical Maintenance of a National Topographic Data Base Using Landsat Images, Alan F. Gregory and Harold D. Moore, AP4 Apr 86 519

Information Systems
Problem-Solving with Remote Sensing: An Update, Warren R. Philipson, AP1 Jan 86 109

Applications of Landsat Data and the Data Base Approach, Donald T. Lauer, AP8 Aug 86 1193

Infrared Video Cameras
Evaluation of the Mid-Infrared (1.45 to 2.0 μm) with a Black-and-White Infrared Video Camera, J.H. Everitt, D.E. Escobar, C.H. Blazquez, M.A. Hussey and P.R. Nixon, AP10 Oct 86 1655

Insect Damage Surveys
An Initial Evaluation of Two Digital Airborne Imagers for Surveying Spruce Budworm Defoliation, F.J. Ahern, W.J. Bennett and E.G. Kettela, AP10 Oct 86 1647

Interactive Editing
ASTRA—A System for Automated Scale Transition, F.W. Leberl, D. Olson and W. Lichtner, AP2 Feb 86 251

International Society for Photogrammetry and Remote Sensing
1984 Commission Reports. Commission II. Val E. Sellers. AP7 Jul 86 1035
1984 Commission Reports. Commission III. James M. Anderson. AP7 Jul 86 1043
1984 Commission Reports. Commission V. H.M. Karara. AP7 Jul 86 1053
1984 Commission Reports. Commission VI. Sanjib K. Ghosh. AP7 Jul 86 1061
1984 Commission Reports. Commission VII. Victor Zsilinszky and Donald Lauer. AP7 Jul 86 1065
Report. 1986 Inter-Congress Symposium of ISPRS Commission V. H.M. Karara. AP11 Nov 86 1785

Interpolation
Performance Evaluation of Two Bivariate Processes for DEM Data Using Transfer Functions. Mohamed Shawki Elghazali and Mohsen Mostafa Hassan. AP8 Aug 86 1213

L

Lake Michigan
Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan. Richard G. Lathrop, Jr. and Thomas M. Lillesand. AP5 May 86 671

Land-Cover Classification
Use of Multitemporal Spectral Profiles in Agricultural Land Cover Classification. Thomas H.C. Lo, Frank L. Scarpace and Thomas M. Lillesand. AP4 Apr 86 535
Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover. Laurie J. Troller and Warren R. Philipson. AP9 Sep 86 1531

Land-Cover Mapping
Utility of AVHRR Channels 3 and 4 in Land-Cover Mapping. A.G. Kerber and J.B. Schutt. AP12 Dec 86 1877

Landsat
Remote Sensing Inland Wetlands: A Multispectral Approach. John R. Jensen, Michael E. Hodgson, Eric Christensen, Halkard E. Mackey, Jr., Larry R. Tinney and Rebecca Sharitz. AP1 Jan 86 87
Satellite Orientation and Position for Geometric Correction of Scanner Imagery. Paul H. Salamonowicz. AP4 Apr 86 491
Geological Mapping Potential of Computer Enhanced Images from the Shuttle Imaging Radar: Lisbon Valley Anticline, Utah. J.D. Curlis, V.S. Frost and L.F. Dellwig. AP4 Apr 86 525
Use of Multitemporal Spectral Profiles in Agricultural Land-Cover Classification. Thomas H.C. Lo, Frank L. Scarpace and Thomas M. Lillesand. AP4 Apr 86 535

Landsat Data
Generating False-Color Composites with a White-Light Optical Processor. F.T.S. Yu and G.W. Petersen. AP3 Mar 86 367
Use of SIR-A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore, South Australia. Glen M. Green. AP5 May 86 659
Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data. Mark Shasby and David Carneggie. AP6 Jun 86 779
Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data. Stephen S. Talbot and Carl J. Markon. AP6 Jun 86 791
Enhancing Landsat Data Acquired Under Very Low Illumination. John M. Miller and Greta J. Burger. AP6 Jun 86 801
An Evaluation of Landsat MSS Ditial Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr. AP8 Aug 86 1146
A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure. Knut Conradsen and Jan Gunulf. AP8 Aug 86 1181
Applications of Landsat Data and the Data Base Approach. Donald T. Lauer. AP8 Aug 86 1193
Image Mapping with the Thematic Mapper. Alden P. Colvocoresses. AP9 Sep 86 1499
A Further Development of the Chromaticity Technique for Satellite Mapping of Suspended Sediment Load. Tommy Lindell, Bert Karlsson, Mats Rosengren and Tom Alfoldi. AP9 Sep 86 1521
Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover. Laurie J. Troller and Warren R. Philipson. AP9 Sep 86 1531
Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000 Scale Image Mapping. Pat S. Chavez, Jr. AP10 Oct 86 1637
Fruit Tree Inventory with Landsat Thematic Mapper Data. Daniel K. Gordon, Warren R. Philipson and William D. Philpot. AP12 Dec 86 1871

Landsat Imagery
Remote Sensing Image/Map Position Locator. Joseph J. Ulliman. AP2 Feb 86 197
Economical Maintenance of a National Topographic Data Base Using Landsat Images. Alan F. Gregory and Harold D. Moore. AP4 Apr 86 519
The Evolving Alaska Mapping Program. Paul D. Brooks and Thomas J. O'Brien. AP6 Jun 86 769

Landscape Diversity
Spatial Diversity Index Mapping of Classes in Grid Cell Maps. Charles J. Robinove. AP8 Aug 86 1171

Land Use Classification
Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover. Laurie J. Troller and Warren R. Philipson. AP9 Sep 86 1531

Leaf Area Index
Spectral Reflectance Patterns of Flooded Rice. R.D. Martin, Jr. and J.L. Heilman. AP12 Dec 86 1885

Leaf Reflectance
Comparison of Leaf and Canopy Reflectance of Subarctic Forests. Kenneson G. Dean, Yuji Kodama and Gerd Wendler. AP6 Jun 86 809
Spectral Reflectance Relationships to Leaf Water Stress. William J. Ripple. AP10 Oct 86 1669

Leaf Water Stress
Spectral Reflectance Relationships to Leaf Water Stress. William J. Ripple. AP10 Oct 86 1669

Lens Distortion
Lens Distortion for Close-Range Photogrammetry. John G. Fryer and Duane C. Brown. AP1 Jan 86 51
System Calibration and Self Calibration. Part I: Rotationally Symmetrical Lens Distortion and Image Deformation. Hartmut Ziemann and Sabry F. El-Hakim. AP10 Oct 86 1617

Linear Regression Applications
The Importance of Measurement Error for Certian Procedures in Remote Sensing at Optical Wavelengths. Paul J. Curran and Alan M. Hay. AP2 Feb 86 229

Line Matching
A Robust Solution to the Line-Matching Problem in Photogrammetry and Cartography. Tony Schenk. AP11 Nov 86 1779

Line Spread Function
Fourier Transform Techniques for the Evaluation of the Thematic Mapper Line Spread Function. Walter H. Carnahan and Guoping Zhou. AP5 May 86 639

Logical Smoothing
The Enhancement of Computer Classifications by Logical Smoothing. Frederick E. Townsend. AP2 Feb 86 213

Los Angeles
Estimating Urban Vegetation Cover in Los Angeles. David E. Brown and Arthur M. Winer. AP1 Jan 86 117

Louisiana
An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr. AP8 Aug 86 1146

Low-Level Illumination
Enhancing Landsat Data Acquired Under Very Low Illumination. John M. Miller and Greta J. Burger. AP6 Jun 86 801

Lowpass Filtering
Fourier Transform Techniques for the Evaluation of the Thematic Mapper Line Spread Function. Walter H. Carnahan and Guoping Zhou. AP5 May 86 639

M

Map Accuracy
Accuracy Assessment: A User's Perspective. Michael Story and Russell G. Congalton. AP3 Mar 86 397
Aerial Verification of Polygonal Resource Maps: A Low Cost Approach to Accuracy Assessment. Thomas H. George. AP6 Jun 86 839
Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data. Leslie A. Morrissey and Laurence L. Strong. AP9 Sep 86 1513

Map Revision
Economcial Maintenance of a National Topographic Data Base Using Landsat Images. Alan F. Gregory and Harold D. Moore. AP4 Apr 86 519
An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L. Nelson May, Jr. AP8 Aug 86 1146

Map Scales
ASTRA—A System for Automated Scale Transition. F.W. Leberl, D. Olson and W. Lichtner. AP2 Feb 86 251
Analysis of Thematic Map Classification Error Matrices. George H. Rosenfield. AP5 May 86 681

Map Symbols
ASTRA—A System for Automated Scale Transition. F.W. Leberl, D. Olson and W. Lichtner. AP2 Feb 86 251

Mapping
Close-Range Mapping with a Solid State Camera. Kam W. Wong and Wei-Hsin Ho. AP1 Jan 86 67
Semi-Automatic Survey of Crop Damage Using Color Infrared Photography. G. Ladouceur, R. Allard and S. Ghosh. AP1 Jan 86 111
ASTRA—A Systm for Automated Scale Transition. F.W. Leberl, D. Olson and W. Lichtner. AP2 Feb 86 251
The Evolving Alaska Mapping Program. Paul D. Brooks and Thomas J. O'Brien. AP6 Jun 86 769
Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data. Mark Shasby and David Carneggie. AP6 Jun 86 779
Aerial Verification of Polygonal Resource Maps: A Low-Cost Approach to Accuracy Assessment. Thomas H. George. AP6 Jun 86 839
Spatial Diversity Index Mapping of Classes in Grid Cell Maps. Charles J. Robinove. AP8 Aug 86 1171
A Further Development of the Chromaticity Technique for Satellite Mapping of Suspended Sediment Load. Tommy Lindell, Bert Karlsson, Mats Rosengren and Tom Alfoldi. AP9 Sep 86 1521
Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System. M.S. Elghazali. AP11 Nov 86 1767

Map Position
Remote Sensing Image/Map Position Locator. Joseph J Ullman AP2 Feb 86 197

Map Verification
Aerial Verification of Polygonal Resource Maps A Low-Cost Approach to Accuracy Assessment Thomas H George AP6 Jun 86 839

Mass Storage
Mass Storage Estimates for the Digital Mapping Era Donald L Light AP3 Mar 86 419

Planning for Optical Disk Technology with Digital Cartography. Donald L Light AP4 Apr 86 551

Mathematical Models
Radarclinometry for the Venus Radar Mapper Robert L Wildey. AP1 Jan 86 41

Calibrating Non-Metric Cameras Using the Finite-Element Method Riadh A Halim Munjy AP8 Aug 86 1201

Measurement Accuracy
Precision of Stereoscopic Height Measurements J C Trinder AP1 Jan 86 75

Microwave Antenna Measurement by Photogrammetry Clive S Fraser AP10 Oct 86 1627

Measurement Errors
The Importance of Measurement Error for Certain Procedures in Remote Sensing at Optical Wavelengths Paul J Curran and Alan M Hay AP2 Feb 86 229

Evaluation of the Effects of Photo Measurement Errors on Predictions of Stand Volume from Aerial Photography James L Smith AP3 Mar 86 401

Metric Cameras
Self Calibration Using the Finite Element Approach Riadh A Halim Munjy AP3 Mar 86 411

Microwave Antennas
Microwave Antenna Measurement by Photogrammetry Clive S Fraser AP10 Oct 86 1627

Mid-infrared Sensitivity
Evaluation of the Mid Infrared (1 45 to 2 0 μm) with a Black and White Infrared Video Camera J H Everitt D E Escobar C H Blazquez M A Hussey and P R Nixon AP10 Oct 86 1655

Mineral Exploration
A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure Knut Conradsen and Jan Gunull AP8 Aug 86 1181

Multispectral Response Testing
Sun Angle View Angle and Background Effects on Spectral Response of Simulated Balsam Fir Canopies K J Ranson C S T Daughtry and L L Biehl AP5 May 86 649

Multispectral Scanner Data
The Tasseled Cap De Mystified E P Crist and R J Kauth AP1 Jan 86 81

Remote Sensing Inland Wetlands A Multispectral Approach John R Hensen, Michael E Hodgson Eric Christensen Halkard E Mackey Jr Larry R Tinney and Rebecca Shantz AP1 Jan 86 87

Issues Arising from Sampling Designs and Band Selection in Discriminating Ground Reference Attributes Using Remotely Sensed Data M L Labovitz AP2 Feb 86 201

The Enhancement of Computer Classifications by Logical Smoothing Frederick E Townsend AP2 Feb 86 213

Generating False-Color Composites with a White-Light Optical Processor F T S Yu and G W Petersen AP3 Mar 86 367

Satellite Orientation and Position for Geometric Correction of Scanner Imagery. Paul H Salamonowicz AP4 Apr 86 491

Economical Maintenance of a National Topographic Data Base Using Landsat Images Alan F Gregory and Harold D Moore AP4 Apr 86 519

Geological Mapping Potential of Computer Enhanced Images from the Shuttle Imaging Radar Lisbon Valley Anticline Utah J D Curlis. V S Frost and L F Dellwig AP4 Apr 86 525

Use of Multitemporal Spectral Profiles in Agricultural Land Cover Classification. Thomas H C Lo, Frank L Scarpace and Thomas M Lillesand, AP4 Apr 86 535

Use of SIR-A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore South Australia Glen M Green AP5 May 86 659

Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data. Mark Shasby and David Carneggie AP6 Jun 86 779

Vegetation Mapping of Nowitna National Wildlife Refuge Alaska Using Landsat MSS Digital Data Stephen S Talbot and Carl J Markon, AP6 Jun 86 791

Enhancing Landsat Data Acquired Under Very Low Illumination, John M Miller and Greta J Burger, AP6 Jun 86 801

An Evaluation of Landsat MSS Digital Data for Updating Habitat Maps of the Louisiana Coastal Zone. L Nelson May Jr AP8 Apr 86 1146

Identification of Two Southern Pine Species in High-Resolution Aerial MSS Data. J S Hughes D L Evans P Y Burns and J M Hill AP8 Aug 86 1175

A Geological Example of Improving Classification of Remotely Sensed Data Using Additional Variables and a Hierarchical Structure Knut Conradsen and Jan Gunull AP8 Aug 86 1181

Multitemporal Data
Use of Multitemporal Spectral Profiles in Agricultural Land-Cover Classification. Thomas H C Lo Frank L Scarpace and Thomas M Lillesand, AP4 Apr 86 535

Fruit Tree Inventory with Landsat Thematic Mapper Data. Daniel K Gordon, Warren R Philipson and William D Philpot AP12 Dec 86 1871

N

National High Altitude Program
Digital Merging of Landsat TM and Digitized NHAP Data for 1 24 000-Scale Image Mapping. Pat S Chavez Jr AP10 Oct 86 1637

National Mapping Program
The Evolving Alaska Mapping Program, Paul D Brooks and Thomas J O'Brien. AP6 Jun 86 769

Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data Mark Shasby and David Carneggie. AP6 Jun 86 779

Non-Metric Cameras
Calibrating Non-Metric Cameras Using the Finite-Element Method, Riadh A Halim Munjy. AP8 Aug 86 1201

North Determination
Determining True and Magnetic North on Aerial Photographs. Frederic R Larson. David A Herman and Kenneth C Winterberger. AP6 Jun 86 829

O

Optical Disk Storage
Mass Storage Estimates for the Digital Mapping Era Donald L Light AP3 Mar 86 419

Planning for Optical Disk Technology with Digital Cartography Donald L Light, AP4 Apr 86 551

Optical Processors, White-Light
Generating False-Color Composites with a White-Light Optical Processor F T S Yu and G W Petersen, AP3 Mar 86 367

Optical Sensors
The Importance of Measurement Error for Certain Procedures in Remote Sensing at Optical Wavelengths Paul J Curran and Alan M Hay. AP2 Feb 86 229

Orthographic Terrain Views
Orthographic Terrain Views Using Data Derived from Digital Elevation Models. Ralph O Dubayah and Jeff Dozier AP4 Apr 86 509

Orthophoto Base Maps
Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell Alaska Carl S Benson and Anthony B Follett AP6 Jun 86 813

P

Parallelism Control
Parallelism of the Stereometric Camera Base to the Datum Plan in Close-Range Photogrammetry. Oguz Multuoglu, AP8 Aug 86 1207

Perceptual Image
Vertical Exaggeration in Stereo Vision Theories and Facts, Humberto Rosas AP11 Nov 86 1747

Permafrost Mapping
Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data. Leslie A Morrissey and Laurence L Strong AP9 Sep 86 1513

Photogrammetric Accuracy
Practical Photogrammetry from 35-mm Aerial Photography. Arthur Roberts and Lori Griswold, AP4 Apr 86 501

Real-Time Image Metrology with CCD Cameras S F El-Hakim. AP11 Nov 86 1757

Photogrammetric Plotting System
Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System. M S Elghazali, AP11 Nov 86 1767

Photogrammetry
The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data, S F El-Hakim, AP1 Jan 86 59

Semi-Automatic Survey of Crop Damage Using Color Infrared Photography. G Ladouceur, R Allard and S Ghosh AP1 Jan 86 111

Self-Calibration Using the Finite Element Approach, Riadh A Halim Munjy. AP3 Mary 86 411

Practical Photogrammetry from 35-mm Aerial Photography, Arthur Roberts and Lori Griswold, AP4 Apr 86 501

Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell, Alaska Carl S Benson and Anothony B Follett AP6 Jun 86 813

Calibrating Non-Metric Cameras Using the Finite-Element Method, Riadh A Halim Munjy, AP8 Aug 86 1201

System Calibration and Self-Calibration Part I Rotationally Symmetrical Lens Distortion and Image Deformation, Hartmut Ziemann and Sabry F El-Hakim, AP10 Oct 86 1617

Microwave Antenna Measurement by Photogrammetry, Clive S Fraser, AP10 Oct 86 1627

Real-Time Image Metrology with CCD Cameras S F El-Hakim, AP11 Nov 86 1757

Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System M S Elghazali, AP11 Nov 86 1767

A Robust Solution to the Line-Matching Problem in Photogrammetry and Cartography, Tony Schenk, AP11 Nov 86 1779

Photointerpretation
Large-Scale Sampling Photography for Forest Habitat-Type Identification, Wm Befort, AP1 Jan 86 101

A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. George H Rosenfield and Katherine Fitzpatrick-Lins, AP2 Feb 86 223

Evaluation of the Effects of Photo Measurement Errors on Predictions of Stand Volume from Aerial Photography. James L Smith AP3 Mar 86 401

Analysis of Thematic Map Classification Error Matrices. George H Rosenfield AP5 May 86 681

Determining True and Magnetic North on Aerial Photographs. Frederic R Larson, David A Herman and Kenneth C Winterberger. AP6 Jun 86 829

Aerial Verification of Polygonal Resource Maps. A Low-Cost Approach to Accuracy Assessment. Thomas H George AP6 Jun 86 839

Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data Leslie A Morrissey and Laurence L Strong. AP9 Sep 86 1513

Accuracy of Population Estimation from Medium-Scale Aerial Photography. C P Lo. AP12 Dec 86 1859

Photographic Cameras

Cessna Aircraft Cabin Door Mount for Photographic and Videographic Cameras. Daniel S Long, John E Taylor and Jack McCarthy AP11 Nov 86 1753

Photo Measurements

Evaluation of the Effects of Photo Measurement Errors on Predictions of Stand Volume from Aerial Photography. James L Smith AP3 Mar 86 401

Predicting Tree Groundline Diameter from Crown Measurements Made on 35 mm Aerial Photography. Gary F Hagan and James L Smith AP5 May 86 687

Real-Time Imaga Metrology with CCD Cameras. S F El Hakim AP11 Nov 86 1757

Photometric Arrays

Radarclinometry for the Venus Radar Mapper. Robert L Wildey. AP1 Jan 86 41

Population Estimation

Accuracy of Population Estimation from Medium Scale Aerial Photography C P Lo. AP12 Dec 86 1859

Position Location

Remote Sensing Image/Map Position Locator. Joseph J Ullman AP2 Feb 86 197

R

Radarclinometry

Radarclinometry for the Venus Radar Mapper. Robert L Wildey AP1 Jan 86 41

Radar Imagery

Radarclinometry for the Venus Radar Mapper. Robert L Wildey AP1 Jan 86 41

Geological Mapping Potential of Computer Enhanced Images from the Shuttle Imaging Radar. Lisbon Valley Anticline Utah. J D Curlis V S Frost and L F Dellwig AP4 Apr 86 525

Use of SIR-A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore. South Australia. Glen M Green. AP5 May 86 659

Opposite-Side SAR Image Processing for Stereo Viewing. J Kevin Fullerton Franz Leberl and Robert E Marque AP9 Sep 86 1487

Radial Distortion

Lens Distortion for Close-Range Photogrammetry. John G Fryer and Duane C Brown. AP1 Jan 86 51

Radiometers

Absolute Calibration of Field Reflectance Radiometers. Ray D Jackson and Philip N Slater, AP2 Feb 86 189

Sun Angle, View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies. K J Ransonm, C S T Daughtry and L L Biehl, AP5 May 86 649

Comparison of Leaf and Canopy Reflectance of Subarctic Forests. Kenneson G Dean, Yuji Kodama and Gerd Wendler. AP6 Jun 86 809

Spectral Reflectance Relationships to Leaf Water Stress. William J Ripple. AP10 Oct 86 1669

Spectral Reflectance Patterns of Flooded Rice. R D Martin Jr and J L Heilman. AP12 Dec 86 1885

Rangeland

Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland. John G Lyon, Jack F McCarthy and Joel T Heinen. AP3 Mar 86 373

Use of SIR A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore. South Australia. Glen M Green AP5 May 86 659

Canopy Reflectance of Two Drought Stressed Shrubs. J H Everitt and P R Nixon. AP8 Aug 86 1181

Canopy Reflectance Characteristics of Succulent and Nonsucculent Rangeland Plant Species. J H Everitt, A J Richardson and P R Nixon, AP12 Dec 86 1891

Range Maps

Aerial Verification of Polygonal Resource Maps. A Low Cost Approach to Accuracy Assessment, Thomas H George. AP6 Jun 86 839

Raster Graphics

Orthographic Terrain Vies Using Data Derived from Digital Elevation Models Ralph O Dubayah and Jeff Dozier, AP4 Apr 86 509

Reflectance

Seasonal Consistency of Salt-Marsh Vegetation Classes Classified from Large Scale Color Infrared Aerial Photographs. P E R Dale, K Hulsman and A L Chandica, AP2 Feb 86 243

Fruit Tree Inventory with Landsat Thematic Mapper Data. Daniel K Gordon, Warren R Philipson and William D Philpot. AP12 Dec 86 1871

Regression Models

Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan. Richard G Lathrop, Jr and Thomas M Lillesand. AP5 May 86 671

Predicting Tree Groundline Diameter from Crown Measurements Made on 35 mm Aerial Photography Gary F Hagan and James L Smith AP5 May 86 687

Remote Sensing

Remote Sensing Inland Wetlands. A Multispectral Approach. John R Jensen Michael E Hodgson Eric Christensen Halkard E Mackey Jr Larry R Tinney and Rebecca Sharitz AP1 Jan 86 87

Problem Solving with Remote Sensing. An Update. Warren R Philipson AP1 Jan 86 109

Remote Sensing Image/Map Position Locator. Joseph J Ullman AP2 Feb 86 197

Issues Arising from Sampling Designs and Band Selection in Discriminating Ground Reference Attributes Using Remotely Sensed Data M L Labovitz AP2 Feb 86 201

A Coefficient of Agreement as a Measure of Thematic Classification Accuracy George H Rosenfield and Katherine Fitzpatrick Lins AP2 Feb 86 223

The Importance of Measurement Error for Certain Procedures in Remote Sensing at Optical Wavelengths. Paul J Curran and Alan M Hay AP2 Feb 86 229

Education in Environmental Remote Sensing. A Bibliography and Characterization of Doctral Dissertations. Robert W Meredeth Jr and Arthur B Sacks AP3 Mar 86 349

Accuracy Assessment. A User's Perspective. Michael Story and Russell G Congalton AP3 Mar 86 397

The Digital Image Analysis System (DIAS) Microcomputer Software for Remote Sensing Education. John A Harrington Jr Kevin F Carlin and Ray Lougeay AP4 Apr 86 545

The Evolving Alaska Mapping Program. Paul D Brooks and Thomas J O Brien AP6 Jun 86 769

35 mm Photography. An Inexpensive Remote Sensing Tool. Richard V Shafer and Sue A Degler AP6 Jun 86 833

On Defining Remote Sensing. Jay Fussell Donald Rundquist and John A Harrington Jr. AP9 Sep 86 1507

Evaluation of the Mid-Infrared (1 45 to 2 0 μm) with a Black and White Infrared Video Camera. J H Everitt D E Escobar C H Blazquez M A Hussey and P R Nixon AP10 Oct 86 1655

Spectral Reflectance Patterns of Flooded Rice. R D Martin Jr and J L Heilman AP12 Dec 86 1885

Resource Assessment

Applications of Landsat Data and the Data Base Approach. Donald T Lauer AP8 Aug 86 1193

Resource Inventory

Applications of Landsat Data and the Data Base Approach. Donald T Lauer AP8 Aug 86 1193

Fruit Tree Inventory with Landsat Thematic Mapper Data. Daniel K Gordon Warren R Philipson and William D Philpot AP12 Dec 86 1871

Resource Maps

Aerial Verification of Polygonal Resource Maps. A Low Cost Approach to Accuracy Assessment. Thomas H George AP6 Jun 86 839

Rice Crops

Spectral Reflectance Patterns of Flooded Rice. R D Martin Jr and J L Heilman. AP12 Dec 86 1885

Runoff

Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover. Laurie J Trolier and Warren R Philipson AP9 Sep 86 1531

S

Salt Marshes

Seasonal Consistency of Salt Marsh Vegetation Classes Classified from Large Scale Color Infrared Aerial Photographs. P E R Dale K Hulsman and A L Chardica AP2 Feb 86 243

Sampling

Issues Arising from Sampling Designs and Band Selection in Discriminting Ground Reference Attributes Using Remotely Sensed Data M L Labovitz AP2 Feb 86 201

A Class of Algorithms for Enumerating Rare Objects Using Spectral and Spatial Data in Real Time. David R Anderson Clair L Wyatt Mohan M Trivedi and Roger K Harshbarger AP8 Aug 86 1158

Performance Evaluation of Two Bivariate Processes for DEM Data Using Transfer Functions. Mohamed Shawki Elghazali and Mohsen Mostafa Hassan AP8 Aug 86 1213

Sampling Photography

Large Scale Sampling Photography for Forest Habitat Type Identification. Wm Befort. AP1 Jan 86 101

Satellite Motions

Satellite Orientation and Position for Geometric Correction of Scanner Imagery. Paul H Salamonowicz AP4 Apr 86 491

Scale Transitions

ASTRA—A System for Automated Scale Transition. F W Leberl D Olson and W Lichtner. AP2 Feb 86 251

Self-Calibration

Self-Calibration Using the Finite Element Approach. Riadh A Halim Munjy AP3 Mar 86 411

Calibrating Non-Metric Cameras Using the Finite Element Method. Riadh A Halim Munjy AP8 Aug 86 1201

System Calibration and Self Calibration. Part I Rotationally Symmetrical Lens

Distortion and Image Deformation. Hartmut Ziemann and Sabry F. El-Hakim. AP10 Oct 86 1617

Sensor Characteristics
Problem Solving with Remote Sensing: An Update. Warren R. Philipson. AP1 Jan 86 109
The Utility of Thematic Mapper Sensor Characteristics for Surface Mine Monitoring. James R. Irons and Ruth L. Kennard. AP3 Mar 86 389

Separability Analysis
Utility of AVHRR Channels 3 and 4 in Land Cover Mapping. A.G. Kerber and J.B. Schutt. AP12 Dec 86 1877

Shuttle Imaging Radar
Geological Mapping Potential of Computer Enhanced Images from the Shuttle Imaging Radar: Lisbon Valley Anticline, Utah. J.D. Curlis, V.S. Frost and L.F. Dellwig. AP4 Apr 86 525
Use of SIR-A and Landsat Mss Data in Mapping Shrub and Intershrub Vegetation at Koonamore, South Australia. Glen M. Green. AP5 May 86 659

Smoothing Operators
The Enhancement of Computer Classifications by Logical Smoothing. Frederick E. Townsend. AP2 Feb 86 213

Soil Erosion
Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland. John G. Lyon, Jack F. McCarthy and Joel T. Heinen. AP3 Mar 86 373

Soil Moisture
Response of Some Thematic Mapper Band Ratios to Variation in Soil Water Content. E. Brad Musick and Ramona E. Pelletier. AP10 Oct 86 1661
Spectral Reflectance Patterns of Flooded Rice. R.D. Martin, Jr. and J.L. Heilman. AP12 Dec 86 1885

Soil Reflectance
Response of Some Thematic Mapper Band Ratios to Variation in Soil Water Content. E. Brad Musick and Ramona E. Pelletier. AP10 Oct 86 1661
Spectral Reflectance Relationships to Leaf Water Stress. William J. Ripple. AP10 Oct 86 1669

Solar Angle
Absolute Calibration of Field Reflectance Radiometers. Ray D. Jackson and Philip N. Slater. AP2 Feb 86 189
Sun Angle, View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies. K.J. Ranson, C.S.T. Daughtry and L.L. Biehl. AP5 May 86 649
Enhancing Landsat Data Acquired Under Very Low Illumination. John M. Miller and Greta J. Burger. AP6 Jun 86 801
Determining True and Magnetic North on Aerial Photographs. Frederic R. Larson, David A. Herman and Kenneth C. Winterberger. AP6 Jun 86 829

Solid-State Cameras
Close-Range Mapping with A Solid State Camera. Kam W. Wong and Wei-Hsin Ho. AP1 Jan 86 67
Real-Time Image Metrology with CCD Cameras. S.F. El-Hakim. AP11 Nov 86 1757

Sonar Imagery
Processing Techniques for Digital Sonar Images from GLORIA. Pat S. Chavez, Jr. AP8 Aug 86 1133

Spatial Data
A Class of Algorithms for Enumerating Rare Objects Using Spectral and Spatial Data in Real Time. David R. Anderson, Clair L. Wyatt, Mohan M. Trivedi and Roger K. Harshbarger. AP8 Aug 86 1158

Spatial Diversity Index
Spatial Diversity Index Mapping of Classes in Grid Cell Maps. Charles J. Robinove. AP8 Aug 86 1171

Spatial Resolution
The Utility of Thematic Mapper Sensor Characteristics for Surface Mine Monitoring. James R. Irons and Ruth L. Kennard. AP3 Mar 86 389

Spectral Band Selection
A Class of Algorithms for Enumerating Rare Objects Using Spectral and Spatial Data in Real Time. David R. Anderson, Clair L. Wyatt, Mohan M. Trivedi and Roger K. Harshbarger. AP8 Aug 86 1158

Spectral Measurements
Sun Angle, View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies. K.J. Ranson, C.S.T. Daughtry and L.L. Biehl. AP5 May 86 649

Spectral Reflectance
Identification of Two Southern Pine Species in High Resolution Aerial MSS Data. J.S. Hughes, D.L. Evans, P.Y. Burns and J.M. Hill. AP8 Aug 86 1175
Spectral Reflectance Relationships to Leaf Water Stress. William J. Ripple. AP10 Oct 86 1669
Spectral Reflectance Patterns of Flooded Rice. R.D. Martin, Jr. and J.L. Heilman. AP12 Dec 86 1885

Stand Volume Estimation
Evaluation of the Effects of Photo Measurement Errors on Predictions of Stand Volume from Aerial Photography. James L. Smith. AP3 Mar 86 401

Stereometric Cameras
Parallelism of the Stereometric Camera Base to the Datum Plane in Close-Range Photogrammetry. Oguz Multuoglu. AP8 Aug 86 1207

Stereomicrographs
Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System. M.S. Elghazali. AP11 Nov 86 1767

Stereophotogrammetry
Capturing Facial Surface Information. Michael Keefe and Donald R. Riley. AP9 Sep 86 1539
Accuracy of Population Estimation from Medium-Scale Aerial Photography. C.P. Lo. AP12 Dec 86 1859

Stereoplotters
Precision of Stereoscopic Height Measurements. J.C. Trinder. AP1 Jan 86 75
Practical Photogrammetry from 35-mm Aerial Photography. Arthur Roberts and Lori Griswold. AP4 Apr 86 501

Stereoscopic Measurements
Precision of Stereoscopic Height Measurements. J.C. Trinder. AP1 Jan 86 75
Opposite-Side SAR Image Processing for Stereo Viewing. J. Kevin Fullerton, Franz Leberl and Robert E. Marque. AP9 Sep 86 1487

Stereoscopic Viewing
Opposite-Side SAR Image Processing for Stereo Viewing. J. Kevin Fullerton, Franz Leberl and Robert E. Marque. AP9 Sep 86 1487
Vertical Exaggeration in Stereo-Vision: Theories and Facts. Humberto Rosas. AP11 Nov 86 1747

Surface Coal Mines
The Utility of Thematic Mapper Sensor Characteristics for Surface Mine Monitoring. James R. Irons and Ruth L. Kennard. AP3 Mar 86 389

Suspended Sediments
A Further Development of the Chromaticity Technique for Satellite Mapping of Suspended Sediment Load. Tommy Lindell, Bert Karlsson, Mats Rosengren and Tom Alföldi. AP9 Sep 86 1521

Synthetic Aperture Radar
Opposite-Side SAR Image Processing for Stereo Viewing. J. Kevin Fullerton, Franz Leberl and Robert E. Marque. AP9 Sep 86 1487

Systematic Errors
The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data. S.F. El-Hakim. AP1 Jan 86 59
Self-Calibration Using the Finite Element Approach. Raidh A. Halim Munjy. AP3 Mar 86 411

T

Target Array Size
Close-Range Mapping with a Solid State Camera. Kam W. Wong and Wei-Hsin Ho. AP1 Jan 86 67

Tasseled Cap Transformations
The Tasseled Cap De-Mystified. E.P. Crist and R.J. Kauth. AP1 Jan 86 81

Terrestrial Data
The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data. S.F. El-Hakim. AP1 Jan 86 59

Texture Extraction
Fruit Tree Investory with Landsat Thematic Mapper Data. Daniel K. Gordon, Warren R. Philipson and William D. Philpot. AP12 Dec 86 1871

Thematic Classification
A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. George H. Rosenfield and Katherine Fitzpatrick-Lins. AP2 Feb 86 223
The Utility of Thematic Mapper Sensor Characteristics for Surface Mine Monitoring. James R. Irons and Ruth L. Kennard. AP3 Mar 86 389

Thematic Mapper Data
The Tasseled Cap De-Mystified. E.P. Crist and R.J. Kauth. AP1 Jan 86 81
Remote Sensing Inland Wetlands: A Multispectral Approach. John R. Hensen, Michael E. Hodgson, Eric Christensen, Halkard E. Mackey, Jr., Larry R. Tinney and Rebecca Shantz. AP1 Jan 86 87
Fourier Transform Techniques for the Evaluation of the Thematic Mapper Line Spread Function. Walter H. Carnahan and Guoping Zhou. AP5 May 86 639
Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan. Richard G. Lathrop, Jr. and Thomas M. Lillesand. AP5 May 86 671
Analysis of Thematic Map Classification Error Matrices. George H. Rosenfield. AP5 May 86 681
Image Mapping with the Thematic Mapper. Alden P. Colvocoresses. AP9 Sep 86 1487
Mapping Permafrost in the Boreal Forest with Thematic Mapper Satellite Data. Leslie A. Morrissey and Laurence L. Strong. AP9 Sep 86 1513
Visual Analysis of Landsat Thematic Mapper Images for Hydrologic Land Use and Cover. Laurie J. Troiler and Warren R. Philipson. AP9 Sep 86 1531
Digital Merging of Landsat TM and Digitized NHAP Data for 1:24,000-Scale Image Mapping. Pat S. Chavez, Jr. AP10 Oct 86 1637
Response of Some Thematic Mapper Band Ratios to Variation in Soil Water Content. E. Brad Musick and Ramona E. Pelletier. AP10 Oct 86 1661
Fruit Tree Inventory with Landsat Thematic Mapper Data. Daniel K. Gordon, Warren R. Philipson and William D. Philpot. AP12 Dec 86 1871

Thematic Mapper
The Utility of Thematic Mapper Sensor Characteristics for Surface Mine Monitoring. James R. Irons and Ruth L. Kennard. AP3 Mar 86 389
Comparison of Leaf and Canopy Reflectance of Subarctic Forests. Kenneson G. Dean, Yuji Kodama and Gerd Wendler. AP6 Jun 86 809

35-mm Photography
Practical Photogrammetry from 35-mm Aerial Photography. Arthur Roberts and Lori Griswold. AP4 Apr 86 501

Predicting Tree Groundline Diameter from Crown Measurements Made on 35-mm Aerial Photography, Gary F Hagan and James L Smith, AP5 May 86 687

35-mm Photography An Inexpensive Remote Sensing Tool, Richard V Shafer and Sue A Degler, AP6 Jun 86 833

Topoclimatic Indices

Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values, Thomas D Frank and Scott A Isard AP3 Mar 86 381

Topographic Data Base

Mass Storage Estimates for the Digital Mapping Era, Donald L Light AP3 Mar 86 419

Economcial Maintenance of a National Topographic Data Base Using Landsat Images, Alan F Gregory and Harold D Moore, AP4 Apr 86 519

Topographic Mapping

Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data, Mark Shasby and David Carneggie, AP6 Jun 86 779

Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell, Alaska, Carl S Benson and Anthony B Follett, AP6 Jun 86 813

Transfer Functions

Performance Evaluation of Two Bivariate Processes for DEM Data Using Transfer Functions, Mohamed Shawki Elghazali and Mohsen Mostafa Hassan, AP8 Aug 86 1213

Transmission Election Micrographs

Mapping from Transmission Electron Micrographs Using the Photogrammetric Plotting System, M.S Elghazali, AP11 Nov 86 1767

U

Utah

Geological Mapping Potential of Computer Enhanced Images from the Shuttle Imaging Radar Lisbon Valley Anticline, Utah, J.D Curtis, V.S Frost and L.F Dellwig, AP4 Apr 86 525

V

Vegetation Classification

Estimating Urban Vegetation Cover in Los Angeles, David E Brown and Arthur M Winer, AP1 Jan 86 117

Seasonal Consistency of Salt-Marsh Vegetation Classes Classified from Large Scale Color Infrared Aerial Photographs, P.E.R Dale K Hulsman, and A.L Chandica, AP2 Feb 86 243

Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values, Thomas D Frank and Scott A Isard AP3 Mar 86 381

Use of SIR-A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore, South Australia Glen M Green, AP5 May 86 659

Fruit Tree Inventory with Landsat Thematic Mapper Data, Daniel K Gordon Warren R Philipson and William D Philpot, AP12 Dec 86 1871

Canopy Reflectance Characteristics of Succulent and Nonsucculent Rangeland Plant Species, J.H Everitt, A.J Richardson and P.R Nixon AP12 Dec 86 1891

Vegetation Mapping

Estimating Urban Vegetation Cover in Los Angeles, David E Brown and Arthur M Winer, AP1 Jan 86 117

Alpine Vegetation Classification Using High Resolution Aerial Imagery and Topoclimatic Index Values, Thomas D Frank and Scott A Isard, AP3 Mar 86 381

Use of SIR-A and Landsat MSS Data in Mapping Shrub and Intershrub Vegetation at Koonamore, South Australia, Glen M Green, AP5 May 86 659

Vegetation and Terrain Mapping in Alaska Using Landsat MSS and Digital Terrain Data, Mark Shasby and David Carneggie, AP6 Jun 86 779

Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data, Stephen S Talbot and Carl J Markon, AP6 Jun 86 791

Utility of AVHRR Channels 3 and 4 in Land-Cover Mapping A G Kerber and J B Schutt AP12 Dec 86 1877

Vegetation Monitoring

Canopy Reflectance of Two Drought Stressed Shrubs J H Everitt and P R Nixon AP8 Aug 86 1189

Evaluation of the Mid-Infrared (1 45 to 2 0 μm) with a Black and White Infrared Video Camera, J H Everitt, D E Escobar C H Blazquez M A Hussey and P R Nixon, AP10 Oct 86 1655

Spectral Reflectance Relationships to Leaf Water Stress William J Ripple AP10 Oct 86 1669

Venus Radar Mapper

Radarclinometry for the Venus Radar Mapper, Robert L Wildey AP1 Jan 86 41

Vetical Exaggeration

Vertical Exaggeration in Stereo-Vision Theories and Facts, Humberto Rosas AP11 Nov 86 1747

Video Digitization

Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland John G Lyon Jack F McCarthy and Joel T Heinen AP3 Mar 86 373

Videographic Cameras

Cessna Aircraft Cabin Door Mount for Photographic and Videographic Cameras Daniel S Long, John E Taylor and Jack McCarthy AP11 Nov 86 1753

Video Imagery

Evaluation of the Mid-Infrared (1 45 to 2 0 μm) with a Black and White Infrared Video Camera, J H Everitt D E Escobar C H Blazquez M A Hussey and P R Nixon, AP10 Oct 86 1655

View Angle Effects

Sun Angle View Angle, and Background Effects on Spectral Response of Simulated Balsam Fir Canopies, K J Ranson C S T Daughtry and L L Biehl AP5 May 86 649

Volcanoes

Application of Photogrammetry to the Study of Volcano-Glacier Interactions on Mount Wrangell, Alaska Carl S Benson and Anthony B Follett AP6 Jun 86 813

W

Water Quality Analysis

Use of Thematic Mapper Data to Assess Water Quality in Green Bay and Central Lake Michigan Richard G Lathrop Jr and Thomas M Lillesand AP5 May 86 671

A Further Development of the Chromaticity Technique for Satellite Mapping of Suspended Sediment Load, Tommy Lindell, Bert Karlsson, Mats Rosengren and Tom Alföldi AP9 Sep 86 1521

Wetlands

Remote Sensing Inland Wetlands A Multispectral Approach, John R Jensen Michael E Hodgson Eric Christensen Halkard E Mackey, Jr, Larry R Tinney and Rebecca Sharitz AP1 Jan 86 87

Wildlife

Vegetation Mapping of Nowitna National Wildlife Refuge, Alaska Using Landsat MSS Digital Data, Stephen S Talbot and Carl J Markon, AP6 Jun 86 791

A Class of Algorithms for Enumerating Rare Objects Using Spectral and Spatial Data in Real Time, David R Anderson, Clair L Wyatt, Mohan M Trivedi and Roger K Harshbarger AP8 Aug 86 1158

Wind Erosion

Video Digitization of Aerial Photographs for Measurement of Wind Erosion Damage on Converted Rangeland, John G Lyon, Jack F McCarthy and Joel T Heinen, AP3 Mar 86 373

—Compiled by Ronald A Antonino

ATTACHMENT 2

American Society for Photogrammetry and Remote Sensing
210 Little Falls Street
Falls Church, Virginia 22046-4398
(703) 534-6617

January 23, 1987

The Honorable Malcolm Baldrige
Secretary of Commerce
Herbert C. Hoover Building
Washington, D. C. 20230

Dear Mr. Secretary:

Your assistance is critically needed if the United States is to maintain its competitiveness, indeed its very being, in the field of Remote Sensing from space.

The American Society for Photogrammetry and Remote Sensing (ASPRS), a national professional, technical and scientific society with 7,000 individuals, is deeply concerned about two vital remote sensing issues which deserve your attention and action.

ASPRS actively supported the Land Remote Sensing Commercialization Act, Public Law 98-365. That law has among its findings and declarations the importance of U.S. leadership in remote sensing and the need for cooperation between the Federal Government and private industry to assure that leadership (*See* 15 U.S.C. 4201(2)(3)(10)).

The society's first concern is that funding provided by Congress in the FY'87 Continuing Appropriation Act (PL 99-500) to implement the commercialization act has not been released in a timely manner. This delay has caused the commercial Landsat operator to scale down activities and reassign key technical scientists and engineers. These actions may be irreversible since no funds have been made available beyond Landsat 6 which is the next of the series planned for launch. A program with such a limited future will hardly attract or retain potential users of an Earth sensing system. Thus, our leadership in remote sensing will surely be lost. We, therefore, urge you to take whatever steps are necessary to assure the proper continuation of the Landsat program.

Another critical remote sensing issue is the conversion of basic Landsat data into a computer compatible format. It is our understanding that 15,000 out of 58,000 selected scenes will *not* be processed by NASA unless further funding is provided.

These historic Landsat data are critical to a multitude of programs, including monitoring and measuring deforestation, flood control, erosion, soil conditions, crop yields, population and fossil fuel exploration. The Earth's resources are limited and our environment is recognized as fragile. Landsat data provides the first comprehensive survey of our planet and an essential tool for future generations which must learn to live on this Earth. At a time of budget restraint, it would appear proper to take advantage of a technology in which the American taxpayer has already invested more than $1 billion and to utilize a data base that will enhance many other Federal programs as well as those of global concern.

As you are charged with monitoring a Landsat "basic data set" archive (See 15 U.S.C. 4272), we respectfully request that you take appropriate steps to affect the prompt conversion of these data into a computer compatible format. We recognize that this may involve the solicitation of other concerned agencies. You may recall that we sent you a telegram last October 1 on this same matter (copy enclosed), but it is our understanding that the issue is still unresolved and even more critical today.

Because of the urgent nature of this matter, copies of this letter are being sent to others as indicated by the attached.

You can be assured of our strong support and assistance with regard to actions to resolve these matters and we urge your prompt attention to these matters.

Sincerely,

Dr. Alan R. Stevens
President

Enclosures

PMS
HON MALCOLM BALDRIDGE 202-377-2000
DEPARTMENT OF COMMERCE
WASHINGTON DC

RE: PRESERVATION OF LANDSAT DATA

IN EXECUTIVE SESSION AND REPRESENTING OVER 7000 PROFESSIONALS THE AMERICAN SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING. REQUEST ACTION BY YOU ON THE FOLLOWING:
LANDSAT DATA WHICH HAS COST THE TAXPAYERS OVER 1 BILLION DOLLARS TO ACQUIRE AND PROCESS IS CONSIDERED A FUNDAMENTAL DATA SOURCE FOR ALL WHO WILL STUDY THIS EARTH TO MAINTAIN AND IMPROVE ITS HABITABILITY. WE UNDERSTAND ONE THIRD OF BASIC LANDSAT COVERAGE (17,000 OUT OF 58,000 SELECTED SCENES) WILL NOT BE PROCESSED BY NASA INTO COMPUTOR COMPATIBLE FORM UNLESS AN APPROPRIATE AGENCY OF THE U.S. GOVERNMENT (COMMERCE DEPARTMENT) INTERVENES. WE THEREFORE URGENTLY REQUEST YOUR INTERVENTION SINCE THE REPORTED DATE FOR DISMANTLING THE PERTINENT NASA FACILITY IS ONLY A FEW DAYS OFF.

DR ALAN R STEVENS, PRESIDENT
AMERICAN SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING
210 LITTLE FALLS ST
FALLS CHURCH VA 22046

Mr. **Hall**. Thank you, Dr. Lillesand. I might first explain to those of you who have been generous enough to give your time and your knowledge that this is Thursday and that there's no votes on the floor of the House today, and many of our members have returned to their districts. And your testimony will be part of the record. They will—they have probably already read it and have been briefed on it.

And because of the time press, I'll save the ranking Republican lady or member because Congressman McCurdy, I think is on a tight schedule. And if you'll yield to the gentleman from Oklahoma, we'll recognize Congressman McCurdy at this time.

Mr. **McCurdy**. Thank you, Mr. Chairman. And certainly I appreciate the indulgence. My problem is not leaving, it's the R&D subcommittee is marking up right now in Armed Services and I'm one of the ranking members of that and I need to be there.

Mr. **Hall**. And we want you there.

Mr. **McCurdy**. And that also could have some impact on this project, too, we hope in the long term.

I'd just like to, as I said in the hearing the other day, this is a national issue and everyone here tends to, I think, agree. We're perhaps getting a verse from the—or a chorus from the choir. We're a part of it also. And I think what we're trying to do in these committee is try to establish a record and make it perfectly clear that there is a need for this system and try to alert the Administration to some of the dangers involved by their inattention and lack of commitment to this particular project.

And it's more than OMB, it's Intelligence, it's other areas that—other users in the government that need to be alerted to this. And it's been a long term effort. And I appreciate the subcommittees and the chairman of the full committee willing to hold the hearings. I was pretty adamant in my insistence, but it didn't take a lot of pressure. I think the full committee supports Landsat, and I think we are concerned about the future.

And the fact that we're doing this jointly with the new subcommittee on International Cooperation is reflective of what we see the broad view, that this is an international concern, that it's a national priority also, and one of competitiveness.

I'd like to say to Dr. Lillesand that Dr. Frank Horton, who is the president of the University of Oklahoma used to be at Wisconsin, also did his Ph.D. work in remote sensing, and so we have a little cross-fertilization there, and I'm sure that you're aware of his work, as Dr. Henderson is.

Because I am in such a rush here I'm going to have to practice triage. I'm going to have to go to the next pressing issue. But I think that it's important that, for the record, that the questions regarding the oil industry and the geological aspects of Landsat and the potential there from a marketing standpoint, and also the need for this should be placed in the record. I'm sure Dr. Henderson can illuminate that and expand upon it.

I know my colleague from Texas is vitally concerned about those issues. The sad thing is that when the government cuts down in this area the most, it's also when industry is cutting down its exploration efforts the most. And so we have a double hit here. And we hope—but that's when the investment should be made, when industry is having difficulty, and that's when government should be involved also.

And certainly our allies have recognized this. And I know Japan, from an economic intelligence standpoint realize this and they're making their investments for the long term future of their country and their economies. I hope that we can do the same.

With that, Mr. Chairman, I'm going to have to leave. Again, I appreciate your efforts and appreciate the gentlemen here testifying today and I will try to return shortly.

Mr. HALL. Represent us where you're going. And now because Miss Schneider may be under the same press, I'll recognize the ranking Republican.

Miss SCHNEIDER. Thank you, Mr. Chairman. Let me begin by saying that I thought the testimony of all three of the witness today was some of the best testimony that I've ever heard, and we're talking about 6½ years of listening to lots and lots of testimony. But I think it was very succinct and clear. But I couldn't help but smile and think, yes, I know all of that and I agree with all of you.

So the challenge before us is to communicate the points that each of you have made to a broader audience. Not just to OMB, but beyond. So I think the first task, if I were to throw the ball back into your court, is one of communicating that need whether it be through Op-Ed pieces in the newspaper or whatever. But I think that we have a sore lack of knowledge, thereby sore lack of public support.

And for the handful of the members on this committee to go around to our colleagues and say, we need you to co-sponsor this bill or to support us on the floor, it's not going to happen if our colleagues have never even heard of Landsat and have no idea of its functions. And I think that one of the—I am often asked a number of questions so maybe you can help me with an appropriate answer here.

One of the questions I was asked, or I think it was one of the witnesses from OMB had said that, we already have thousands of images of the geologic formations and various geological features and that we don't really need any more images. Of course, I had an answer that that's not the only function of it. It's useful for currents and for fisheries and for EEZ state purposes for mining and that sort of thing.

But how would one answer the fact that there are already thousands of pictures of the geologic formations, and for the most part they don't move except for every thousand years or so?

Mr. HENDERSON. I think we'd answer the following way that, as I said in my testimony, the data we have already is only part of what we need. We don't have a global radar picture. We don't have a global thermal IR measure of the silicate concentration in the rocks and soils that the thermal IR package that Landsat might have.

Miss SCHNEIDER. And why do we need that?

Mr. HENDERSON. Because basically what we are seeing in these things is an ability to measure the different minerologic—in the case of geology—different minerological content of the soils and rocks. The shortwave infrared—excuse me, the very near infrared bands give us iron oxides, for example. The shortwave infrared give us clays and carbonates, for example. And the thermal IR will give us the silicate minerology.

Basically it's giving us new information we don't presently have anywhere, in a sense, to map different parts of rocks and soils more adequately. The thousands of images and data that exists, some of that will always be of use to us, and that's quite clear. And yes, Mr. Wright's comments that faults don't move except in California every thousand years or whatever it is is somewhat right—excuse me, that's a pun.

In any case, what I meant to say is that, again we need these other data sources to complete our information source to do our work adequately and we don't have those yet. And then also Landsat, for example, to my understanding has not yet even covered the world, cloud-free cover for the thermatic mapper. We've had that for five years.

So we need continued coverage and it may take several satellites or several satellite systems to do that. And we need more coverage globally and more ability to do that. So I'd say, we haven't got there yet.

Miss **Schneider**. Secondly, why don't you give me your most compelling arguments as to why it would be so bad for us to rely on information from the Japanese or the French.

Mr. **Henderson**. I don't think it's bad to rely on the information. It's going to be good information, as long as we can get it. The question is whether or not at some point in time as these systems improve they would determine that it is in their own interest to keep the data to themselves. They have told us they won't do that. I'd like to believe them. We work with them and we hope that they won't do that. But we need to continue to emphasize that.

But I say again, without a civil U.S. program, maybe they won't see why they should give the data back to us.

Miss **Schneider**. One of the greatest frustrations of many people that are involved in the sciences and research in one way or another is that there is, if the federal government is involved, there is constantly a lack of continuity and commitment, as Dr. Lillesand had pointed out. There are some of us who are part of the competitiveness caucus, which I co-founded here in Congress, to change some of that commitment and highlight the value of science and the value of long term commitments to research.

One of our proposals is to make sure that the R&D tax credit, rather than be a three year tax credit be an unlimited tax credit in terms of time. Are there any other things that you can suggest that might be able to force the government's hand in being more regular in its management of the sciences, and in particular Landsat?

Mr. **McCandless**. I might add that it doesn't just apply to the scientific community. It applies to the civil sector, too. I've been in both places, spending a lot of my career at NASA. And the two groups are much closer together than you might imagine.

You're not going to get a strong commitment from the civil sector, from a strong industry unless they see that there's going to be some follow through and projection. This whole concept of user charges keeps coming up. I think the right answer is, you could certainly mount a case for strong user charges if there was a real indication that the program was going to have a 20-year lifetime.

It's not that different from the scientific community. A man's not going to commit, or a lady's not going to commit her scientific career to an objective that has a three year lifetime. So they'll pursue other interests.

Miss **Schneider**. Well, one of the frustrating things is that the assumption has been that in terms of high technology the United States leads the world, when in fact, as all three of you have mentioned, we have made great movement, but unfortunately we have not maximized our potential as a result of some of the findings that we have made or developments that we have made.

And I guess what seems so frustrating is that we've already lost the markets internationally on seven out of the 10 key areas that the United States had targeted in the area of high tech. And we've also lost our surplus in just 5 short years. We had a surplus 5 years ago of 7½ billion. Now we have a deficit of eight billion in high technology export.

So it seems to me that you have a compelling case from that angle also. But we keep getting stuck with being in the situation, who will pay. I mean, we are grappling, on the other hand, in trying to reduce the deficit. So if we make a commitment for more than one year, if we make it for three or five years or whatever, which is within the realm of possibility, I believe, where do we get the money?

And unfortunately, many of you folks in this room are not willing to recognize that there's only one big place that seems to have a lot of money in the budget. And if you don't have the courage to go after it, I can't go after it alone. So you have to recognize that it does no good to come here and ask for more money without suggesting where we're going to get it, and then making some moves to assist in getting it.

Mr. **Lillesand**. One of the fundamental problems that we've had with respect to the community of the remote sensing specialists, if you will, is that it is inherently diffuse. It basically serves the public good at the state and local level. It has historically been disaggregated, and so the loud silence you hear in the political arena doesn't mean it doesn't exist. It's just that it is disaggregated.

I should also say that this question about reliance of data from other sources. We certainly do emphasize the need for competitiveness internationally. But again, from a scientific standpoint we should point out the need for cooperation as well.

Miss **Schneider**. Yes.

Mr. **Lillesand**. In the terms of, for example, the SPOT satellite, it is highly complimentary to Landsat technically. That is to say, that while it has better resolution than our system, it doesn't have the spectral band. It also at any given time, half the earth's surface is covered by clouds. It's good to have two systems up there, avoid technical failures.

The other thing is that to try to encourage venture capital investment in a value added service community, it's important that we have SPOT, Landsat and other systems operating simultaneously so we avoid the sole source problem.

So it's a matter of time. If we get out of this game, I'm willing to wager, at least in my biased opinion, it will just be a matter of time before we're back in it for scientific reasons, if not economic.

Miss **Schneider**. Well, let me just close by adding that I, too, have to run to a markup. I'm on a fisheries committee where we deal with NOAA. And Mr. McCandless, I will say in terms of the oceans industry, I am of the opinion that you perhaps have not been speaking loud enough because we have allowed the NOAA budget on oceans and ocean related research to be decimated.

Mr. **McCandless**. Yes, especially in the fisheries area, it's terrible

Miss **Schneider**. Especially to the fisheries area. And I have not heard that outcry. And here when we are discussing who some of the user parties are of the Landsat capabilities, whether it be agriculture or defense or whatever, I think that Mr. McCandless, you know that NOAA is not putting out any more research vessels. They're saying the Defense Department is going to do it.

We also know that in terms of looking at the EEZ, much of that work is also now not only being done by universities but by the Defense Department, and that there is a real controversy about how much of that material is becoming classified.

So if you're talking about civilian usage for state and local governments, for fisheries, for agriculture, et cetera, what is the trend that we see happening? Or is it that just people aren't seeing this? But if we allow much of this scientific data to be classified, what is our future for civilian potential?

Mr. **Henderson**. I just want to make one comment. You asked about where to get money.

Miss **Schneider**. Good, you've got the answer.

Mr. **Henderson**. And I don't have the answer. No, I don't have an answer—well, I do have an answer for it.

Miss **Schneider**. OK.

Mr. **Henderson**. I've been coming here for 11 years and I'm frustrated with the fact for the first time in Tuesday's hearing the agencies were able to stand up with the permission, if they get permission from OMB, to say they have a need. They use the data. Interior uses the data, Energy uses the data. But they're not allowed to contribute to this budget problem of subsidizing the payment to make that thing work.

I don't know whether it should all come out of Commerce or not. But it should come out of the United States government who uses the data. At least the DOD is willing to step up and say they ought to pay part of the bill. The rest of the agencies should too, in my opinion.

Miss **Schneider**. OK, thank you. Thank you, Mr. Chairman, I have no further questions. Thank you all for your testimony.

Mr. **Hall**. Thank you, Miss Schneider. I'll be very brief. I just want to get on to the record a few things that I think are of import. And I guess we're talking about budgets. McCurdy's just gone to do something about the budget, if and the gentlelady can give us some suggestions as to where to cut, work toward the budget. And we all have different ideas.

With respect to the exploration budget though of oil and gas of which you're considered an authority, just for the record, what is the overall industry exploration budget? What is that figure, round figure?

Mr. HENDERSON. If I may, I'd like to ask Mr. Stewart, from where I get a lot of my wisdom from to answer that question.

Mr. HALL. Sure. A lot of times you go to a Texan to get the best information. [Laughter.]

Mr. STEWART. I have heard many numbers. When you talk about overall exploration budget you're obviously talking about millions of dollars. I really don't know the latest figure on that. Now obviously the remote sensing budget is some small piece of that, but it is in the tens of millions of dollars in terms of the data that we buy and the systems that we buy to help process that data.

Mr. HALL. The budget that you devote to Landsat, is that increasing or decreasing or holding its own?

Mr. STEWART. It's quite remarkable because that budget is actually increasing. Even though many of our budgets are decreasing we're using Landsat much more in an operational sense, and the number of projects that we apply the Landsat data to has increased yearly since its inception.

Mr. HALL. Let me ask maybe any of you. Given your experience, particularly again, Dr. Henderson, with the Japanese oil and gas industry. What's your opinion about the feasibility of maybe a United States-Japanese joint venture in earth remote sensing? Or United States-French joint venture?

Mr. HENDERSON. At this point in time I don't know the answer to the question. I will say that both—the French made a specific effort in 1977 to fly a joint remote sensing program with the United States and were turned down.

Following the Seasat disaster—I call it a disaster because we don't have radar in this country—the Japanese made a proposal at the end of the Carter Administration for a joint mission and were turned down. Both of those countries have stated in not so unkind terms that since they were turned down, they'll build their own damn systems.

So whether or not they turn around now and want to go joint venture, I don't know. Especially if we're dropping out of the game. What are they going to joint venture with?

Mr. HALL. What do we bring to the table?

Mr. HENDERSON. What do we bring to the table?

Mr. HALL. And one other thing that I think is of interest to us, Dr. Lillesand, on page 5 of your testimony you state that the state and local governments are evolving toward substantial applications of remotely sensed data, particularly in the area of natural resource management. Yet we note that currently only about 1 percent of the total data sales are attributable to state and local government.

When will this substantial application occur?

Mr. LILLESAND. Materialize.

Mr. HALL. When will we see it, or will we?

Mr. LILLESAND. We never—we'll see it manifest itself with respect to the purchase of SPOT data if we're on the current path. The national governors association has a policy statement on Landsat, and basically it says, we lack the training, we lack the funds, but the big thing is, we lack the continuity.

And we have tremendous documentation of potential utility. As we alluded to, we've come a long way in terms of information management, but we still aren't going to see the investment in any sort of operational sense until there's a guarantee of continuity of high resolution data for these purposes. And we'll see it probably manifest itself in the form of the purchase of SPOT data if we don't do something. It's coming.

Mr. HALL. We have Congressman McMillen who's joined us and who's not had the opportunity to hear your testimony, but will have, of course, the full text of your testimony, and I certainly would recognize our colleague, Tom, at this time if you had any questions or any suggestions.

Mr. MCMILLEN. Thank you very much, Mr. Chairman. As you said, I really haven't had a chance to review the testimony but just on the general sense, I am interested. What does the United States lose without a multispectral remote sensing system, particularly in the areas of technological development and resource development? In a general sense, my concern is what does it mean to the country long term to be dependent on the French and Japanese for this?

You might have asked that question but I'd just like to hear your response.

Mr. HENDERSON. Again, I think we answered that question, or I did in attempt to saying we have no problem with seeking data from the French and the Japanese as long as they were willing to comply with the open skies policy. But that that could be put at risk if we no longer have a U.S. program. Could be, not will necessarily.

Mr. MCMILLEN. Mr. McCandless.

Mr. MCCANDLESS. I think you're kind of naive if you believe that if there's a strong economic advantage or other advantage—let's just take the economic one—based on what we're watching at the moment, this whole trade imbalance situation, that foreign government wouldn't take advantage of it. We do, why wouldn't they?

Mr. LILLESAND. From a purely technical design of systems standpoint, and if my goal were to provide the greatest economic advantage to U.S. industry throughout the value added sector and down to the users, I would like to be in control of the technical design of the system.

Mr. MCMILLEN. A couple more questions along the lines of geology and what it means. Maybe you can give me a better understanding of the potential of Landsat. It said that so many of the strategic minerals and the future of strategic mineral exploration is located in Africa. What is the ability through satellite to really discern where these minerals may be? I mean, how extensive and how useful is this technology with regards to mineral search?

Mr. HENDERSON. Again, we consider remote sensing basically an improvement on our ability to do geological mapping in some areas and regions. This is particularly true outside the United States, especially in areas where we can't get into, or don't have access, or there are no good maps. It allows us to do broad scale regional mapping in a way to target where we may wish to spend more time with other tools and other techniques. In and of itself it's not a magical tool, but it a very advantageous tool to the problem that you just mentioned.

Mr. **McMillen**. Can you cite any specific examples of where it's been particularly useful in the past in terms of identification of oil, gas, whatever? I mean, in terms of potential sources of these minerals.

Mr. **Henderson**. Let me turn to again, a representative of the GEOSAT committee board, Mr. Stewart from Sun who is in that business.

Mr. **Stewart**. There's really an answer there for both the mineral side and the hydrocarbon side because as we extend our knowledge and we extend the bands out into near infrared and get the very narrow discrete bands there, we're able to pick up alteration minerals. And these are key minerals that are tied to mineral deposits.

So we can do mapping with increased spectral information and increased spatial information, where we can see smaller and smaller areas. With that information we can do not only broad geologic mapping but very specific mapping for these type of mineralizations and geometric situations that will point us to those deposits.

Mr. **McMillen**. Vis-a-vis Africa, just extending that question for a second. I mean, obviously in our country so much of our land mass has been explored and has really been, in terms of potential areas have been identified. How about in Africa? I mean, what are your conclusions based on the data that you have collected thus far on Africa?

Mr. **Stewart**. I'll answer that question on Africa, but let's not leave the United States. Because the type of mapping that we've done in the past has been without this particular type of tool. So that basic geological maps that we've produced really well over the U.S. does not include information that we can add with better satellites.

So there are some more things that we can do in this country. In terms of Africa, we're looking ourselves at different parts of Africa and Asia for hydrocarbon deposits, and we're looking for specific alterations that we can detect that has to do with hydrocarbons drifting to the surface. These are the types of techniques that we're developing because we're right at the edge of that technology.

Mr. **McMillen**. Can you really discern that a certain chromium or platinum or gold would have a certain topography? I mean, is there a way that you can discern almost a mineral specific analysis?

Mr. **Stewart**. Yes, there are very distinct alteration of mineralizations of clay type minerals that you can definitely point to these type of deposits. If you can detect that mineralization, you can put yourself close into that ballpark.

Mr. **McMillen**. Based on the data that you have at this point in time, is it true that strategic minerals like chromium and platinum, titanium are located through the African continent. I mean, we hear about South Africa, but are these minerals really located throughout the continent?

Mr. **Stewart**. I'm really not qualified to——

Mr. **McMillen**. Just curious. I was digressing a little bit.

Mr. **Henderson**. Congressman McMillen, I would hope that you might direct that question to Dr. Taranik who's very much interested in remote sensing of strategic minerals, when he testifies.

Mr. McMILLEN. One more question, then I'll finish up. As you project the development of remote sensing systems worldwide, whose data will the geological community buy in the 1990, SPOT, Landsat or the Japanese? And then the second question is, what portion of sales from the oil and gas community do you think the Landsat will capture in the 1990s.

Mr. HENDERSON. I think the first question we've already discussed. We will buy all data sets that are available because they're complimentary in large measure. And where they overlap we'll buy them partly as a function of global distribution. They simply will not collect data over all of the world at the same rates at the same time and we still have many gaps in our coverage of the world.

I didn't catch your second question.

Mr. McMILLEN. What portion of sales from the oil and gas community do you think that Landsat will capture in the 1990s?

Mr. HENDERSON. What portion of Landsat data sales?

Mr. McMILLEN. What portion of sales from the oil and gas community, that's correct. In terms of all remote sensing.

Mr. HENDERSON. Of all the users? I think the relative proportion will go down because of the very thing that Dr. Lillesand was talking about. The other users are going to come up as they begin to use this data. So proportionally, it will be lower, but in actual amount I'm quite sure it will be more.

Mr. McMILLEN. Thank you, Mr. Chairman.

Mr. HALL. Thank you. We do certainly thank this fine group, and join in the accolades that Ms. Schneider pitched to you. Thank you for your input. And Harry Stewart, thank you, and convey our best wishes to our friends at Sun. And this time we'll have the second panel.

We have been joined by Congressman Ron Packard and Richard Stallings. Thank you gentlemen for appearing.

Our next panel is David Julyan of the SPOT Image Corporation; no stranger to the Hill. And we look forward to hearing from you, Mr. Julyan. I'd like to recognize you. I think you've been in attendance here—recognize you to be as brief as you can for your general presentation, and I assure you that we'll drag a lot of information out of you with questions.

STATEMENT OF DAVID. S. JULYAN, SPOT IMAGE CORP., RESTON, VA

Mr. JULYAN. Thank you, Mr. Chairman. I remember my days on the Hill well enough to believe that.

My name is David Julyan——

Mr. HALL. I just thought I'd warn them that you're no stranger up here.

Mr. JULYAN. My name is David Julyan. I'm the vice president for sales and marketing of the SPOT Image Corporation in Reston, Virginia. I will summarize the testimony that we've presented to the committee this morning. It does give you a relatively detailed explanation of the SPOT program, the satellite, the ground segment, and the sales and marketing activity, as well as a brief explanation of our commercialization policy.

The SPOT program was conceived in 1977 by the French space agency, CNES, and from its inception was designed as the world's first commercial remote sensing venture. With the backing from the governments of France, Sweden and Belgium, along with several private shareholders, the program was implemented to design, assemble, launch and operate a state of the art remote sensing satellite.

Early in the program it was determined that while government coordination and resources were necessary to launch the program and the satellite, proper commercialization of the industry required that a private company, not a public agency, should handle the data distribution, the sales and marketing. As a result, in 1982 SPOT IMAGE, our parent corporation was created and was given a worldwide exclusive distribution license for all the data coming down from the SPOT satellite. The satellite itself is owned and operated by the CNES.

The commercial distribution network which developed is anchored by SPOT IMAGE in France, SAT-IMAGE in Sweden, the SPOT Image Corporation in Reston and a network of over 40 worldwide distributors. The satellite itself was launched last February on the last Arian-1 rocket out of French Guiana. The payload of the satellite consists of two identical HRV, or High Resolution Visible instruments.

We have two modes of operation. One collects the 10 meter panchromatic black and white data, which now represents the highest resolution available to the civilian world. The second mode is a multispectral mode at 20-meter ground resolution.

The SPOT ground segment consists of our mission control center, which is located in Toulouse, and primary receiving stations in Toulouse and Kiruna. Additional receiving stations are already operational, two of them in Canada. And between now and the end of this year, we expect to open up additional stations in mainland China, India, Pakistan, probably the Canary Islands and probably Saudi Arabia.

Additional operations in 1988 with ground stations should include receiving capability in Brazil, Japan, Australia, South Africa and Thailand. Additional countries are discussing the possibility of direct reception of SPOT.

For those areas where we do not have direct visibility of the satellite we do have an on board tape recorder which can acquire data and then transmit it later when it passes over either Kiruna or Toulouse.

SPOT distributes its data under Open Skies, and Nondiscriminatory Access. I won't go into a description of the policy because I know by now you've had it explained to you, if you didn't understand it before we started. SPOT Image Corporation in Reston, Virginia is the only subsidiary of SPOT IMAGE. It was created because of the significance of the U.S. market.

We estimate that over 50 percent, or approximately 50 percent of our worldwide revenues are likely to come from the U.S. market. In addition to that, we also recognize that as a very sophisticated market that it is in this country that many new ideas and new products based on remote sensing and based on SPOT data will be developed. To properly serve that market SPOT Image Corporation was established as a Delaware corporation in 1983.

Activities at Reston include image processing, the maintenance of our own archive, and handling the direct relationships with all U.S. users. We do have an exclusive distribution of all SPOT data regardless of where it is acquired in the world, and supplying that data to all the U.S. users.

The only other thing I would like to say in my opening statement is that remote sensing technology has a long history. It actually dates back into the last century when a Frenchman, Mr. Nadar went up in a hot air balloon over Paris. Since that time the technology has developed. Modern remote sensing technology and the civilians access to it had its beginning with the ERTS-1 launch back in 1972.

We're now experiencing a period in the development of that technology where the initial R&D projects and studies are turning into a commercialized industry where we can take this technology, turn it into a tool and provide that tool as an asset, an assistance to decision makers in a variety of applications.

This is a transition period. As we leave the government sponsored projects of the 1970's and enter into what will be a multi-billion dollar industry by the turn of the century. Transitions are always difficult. When the required resources are as great as they are in our industry, the obvious and recurring questions are, who takes the risk? Who shares in the profits?

The correct answer has to be, everyone. Governments, shareholders of private companies, the suppliers of data, the value added firms, all of our employees, and of course, the ultimate users themselves. We all have to share in this bet or none of us will win.

A recent article presented SPOT's reaction to EOSAT's funding crisis as one of gloating, grins and rejoiced. That's wrong, silly and short-sighted. The commercialized remote sensing industry is in it's early stages. It has successfully evolved from ERTS-1, but it still has a long way to go. SPOT's success is not dependent on Landsat's failure. Our planning, beginning in 1977 always was and still remains based on the existence of a strong Landsat program.

We are trying to build a multibillion dollar industry. We need multiple sources of data. In fact, in many applications, as you've been told this morning, SPOT and Landsat complement each other. This is not to say that we don't look forward to competing with EOSAT. We are aggressive and we are entrepreneurial. But if EOSAT is forced to shut its doors, that is not good news for anybody.

Although SPOT and other corporation involved in what is already a $100 million a year industry will take the appropriate actions to continue positive momentum, the overall effect that this is going to have is not helpful. SPOT IMAGE is a global corporation. We base on international marketing activity by providing the same product, although we will influence it to the local users.

This is not just an American technology, however. The SPOT program, although coordinated back in 1977 first by CNES, resulted in the design, assembly and launching of a system led by the French but including contributions from people of many different countries. That attitude continues to be reflected in our sales and marketing operation today.

I hope in your questions we have an opportunity to talk about some of the applications that we see as the cornerstones for this industry. I won't go through them now except to say that we've identified them, we are happy with the current status of our sales activity in a variety of different applications. We are on target, and we are encouraged about the marketplace's use of remote sensed data. SPOT data obviously is my primary concern, but I am also concerned about the whole industry.

And we also believe very strongly in the following. This will happen. The underlying excitement about our industry, which perhaps doesn't get addressed too much is the following. What you are seeing here is the culmination of developments in space, computer, optics and sensor technology. This didn't exist 30 years ago. This industry is young. It's a new industry but it will be here in the future and it will be a multibillion dollar a year industry.

I thank you, Mr. Chairman.

[The prepared statement of Mr. Julyan follows:]

PRESENTED AS TESTIMONY TO THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURAL RESEARCH AND ENVIRONMENT, AND THE SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION.

APRIL 2, 1987

PRESENTED BY DAVID S. JULYAN, VICE PRESIDENT
SPOT IMAGE CORPORATION

THE SPOT PROGRAM: COMMERCIALIZATION OF REMOTE SENSING

SPOT Image Corporation *1897 Preston White Drive • Reston, Virginia 22091-4326 • (703) 620-2200*

INTRODUCTION

The SPOT program was conceived in 1977 by Centre National d'Etudes Spatiales (CNES), the French space agency, as the world's first commercial remote sensing venture. With backing from the governments of France, Sweden and Belgium, along with several private shareholders, the program was implemented to design, assemble, launch and operate a state-of-the-art remote sensing satellite.

Early in the program it was determined that while government coordination and resources were necessary to launch the program and the satellite, proper commercialization of the industry required that a private company, not a public agency, should handle data distribution, or "sales and marketing." As a result, in 1982 SPOT IMAGE was created to hold and manage worldwide distribution rights of SPOT Data. The commercial distribution network which developed is anchored by SPOT IMAGE in France, SPOT Image Corporation in the U.S., and SATIMAGE in Sweden, and consists of over 40 other local distributors around the world.

THE SPOT SATELLITE SYSTEM

The SPOT 1 satellite was launched on an Ariane rocket into sunsynchronous orbit on February 21, 1986. Orbiting at an approximate altitude of 517 miles, the satellite covers the globe in 26 days over 369 orbital tracks.

The satellite's platform provides support for the payload, including power supply, precision orbit and attitude control, three-axis stabilization, and ground control command reception.

The payload contains two identical High Resolution Visible, or HRV instruments. The HRVs consist of a telescope, an adjustable mirror to control viewing angle, and thousands of individual detectors. Each detector measures light reflected from a 10 meter by 10 meter area on the Earth's surface, and converts that measurement to an electronic signal. This signal is then digitized and either recorded by onboard tape recorders or transmitted directly to ground receiving stations. The image data are transmitted at a rate of 50 megabits per second in the X-band at a frequency of 8 GHz. After processing, the data are converted to commercial products in the form of computer compatible tapes or in a variety of photographic formats.

The detectors within each HRV are arranged in a multilinear array. Imaging is performed by the pushbroom technique in which the detector arrays simultaneously collect an entire image scanline of data perpendicular to the satellite's path. The successive scanlines forming the image are read at regular intervals with the satellite's forward motion providing the along track scanning. This advanced solid state sensor design is a significant improvement over the mechanical scanning assemblies used in other remote sensing systems.

The HRVs operate independently, each with the capability to produce panchromatic or multispectral images. A standard image, when acquired from a vertical viewing angle, covers a ground area of 60 km by 60 km and is composed of several thousand picture elements, or pixels. Each pixel contains an 8 bit digital value corresponding to the light reflected from that area of the Earth's surface.

When operated in the panchromatic mode, the HRV filters incoming light to include a wavelength range from .51 microns to .73 microns. A black and white panchromatic image has a pixel size, and thus ground resolution, of 10 meters by 10 meters, detailed enough to detect objects the size of half a tennis court. This is nine times more detailed than images available from other civilian satellites.

When imaging in the multispectral mode, incoming light is filtered into three individual wavelength bands: green, which ranges from .50 to .59 microns; red, from .61 to .68 microns; and near infrared, from .79 to .89 microns. The readings from each two consecutive detectors are combined in the multispectral mode to produce an image with a pixel size and ground resolution of 20 meters by 20 meters.

The adjustable mirror located at the entrance to the telescope allows each HRV to acquire images from 91 different viewing angles, in .6 degree increments, covering a range of 27 degrees on either side of the satellite's vertical axis. This significant innovation greatly increases the image acquisition opportunities.

During vertical viewing, each HRV images an area 60 kilometers wide. When the HRVs are in the "twin vertical viewing" configuration, the image swath is 117 kilometers wide with a 3 kilometer center overlap. Using the mirrors to adjust the viewing angle SPOT can acquire off-nadir images anywhere within a 950 kilometer swath, and can image the same scene from several different orbital paths. This means that SPOT can revisit, or acquire repeat images of the same area on the average of once every two and one half days.

In addition to this rapid revisit capability, off-nadir viewing is used to acquire images of the same area from two different angles. Called a stereopair, these images appear in 3-dimensions when viewed through a stereoscope. This unique capability is providing a tool of great value for terrain interpretation in geology, hydrology and cartography.

At a maximum viewing angle of 27°, image width increases to approximately 80 kilometers. During ground processing, geometric distortions in the raw data resulting from off-nadir viewing are corrected. This restores the relative locational accuracy of the data, and the corrected image appears as though it were acquired from a vertical viewing angle.

THE SPOT GROUND SEGMENT

The ground segment of the SPOT system consists of a global network of control stations, receiving stations, image processing centers and data distributors. The SPOT Mission and Operations Control Center is located in Toulouse, France. This facility is responsible for satellite orbital control, payload programming for image acquisition, and overall coordination of ground facilities.

Direct receiving stations receive transmissions of image data from the satellite as the data are acquired by the HRVs. The satellite must be within a station's zone of visibility for this to occur. This zone, roughly 2500 kilometers in radius around each station, is determined by the satellite's position relative to the horizon, allowing radiometric reception by the station's antennae.

Receiving stations currently in operation are located in Toulouse, France; Kiruna, Sweden; and two in Canada, Prince Albert, Saskatchewan and Gatineau, Quebec.

The stations in Toulouse and Kiruna also have the capability to receive playback from the onboard tape recorder, and thus receive image data acquired from anywhere in the world.

SPOT program plans include expansion of this ground station network. Receiving stations scheduled to become operational during 1987 are located in China, India, Pakistan, Saudi Arabia and the Canary Islands. Stations scheduled to begin operations during 1988 include Brazil, Japan, Australia, South Africa and Thailand.

Discussions are underway to build additional SPOT receiving stations in Argentina, Ecuador, Egypt, Israel, Kenya and Mexico.

SPOT DATA PRODUCTS

The raw image data transmitted from the satellite are processed to a variety of levels depending on users needs. These data are either wide-band panchromatic (black and white) with 10 meter resolution, or 3-band multispectral (color) with 20 meter resolution.

Level 1A processing involves the application of calibration factors to the image data to normalize individual detector responses. Level 1B processing involves detector normalization and the application of geometric corrections to compensate for the effects of rotation and curvature of the Earth, viewing angle, and smearing due to orbital motion.

Two levels of precision processing are also available. Level 2 image data receive the processing described above, and are then oriented to true north and "corrected" to one of several standard map projections utilizing ground control points. Level S processing involves precision coregistration of multidate scenes covering the same area.

The image data are made available on a variety of media, chosen on the basis of existing user needs. These media currently include computer compatible tapes, photographic prints and transparencies. Additional product media are being developed in response to advances in the industry and the increasing needs of the user community.

SPOT DATA DISTRIBUTION

SPOT Data distribution is performed according to the U.N. policies referred to as "open skies" and "nondiscriminatory access to data." As described previously, data are made available to users through a worldwide network of distributors, each covering a specific geographical area. This system was established to ensure that distributors can tailor their services and products to the specific needs of the users in their area. Worldwide commercial activity is coordinated by SPOT IMAGE, the parent company located in Toulouse, France.

SPOT Image Corporation in Reston, Virginia is the only subsidiary of SPOT IMAGE, and is the exclusive distributor of SPOT Data to the U.S. market. SPOT

Image Corporation was established because the U.S. user community is recognized as the largest and most advanced in the world. Because of this status and the increasing U.S. applications research, it is anticipated that U.S. users will constitute 50% of the world market for SPOT products.

Activities at the Reston facility include image processing, the maintenance of an in-house archive, filling clients' orders from that archive, taking clients' satellite programming requests for specific acquisitions not found in the archive, and scheduling image acquisition by SPOT during passes over the U.S. SPOT Image Corporation supplies image data from anywhere in the world, either from the in-house archive or through connections with SPOT's worldwide network.

SPOT Image Corporation is also extensively involved with exploring and developing new markets and applications. This type of industry development activity involves interacting with all components of the industry, from the data users to the hardware and software developers and the value-added companies.

THE INDUSTRY FUTURE: SPOT AND LANDSAT

Remote sensing is not just an American technology; it is a global technology and must be recognized as such to ensure its continuity and the increasing recognition of its benefits. The design and operation of the SPOT system reflects this important perspective, from its worldwide network of receiving stations and distributors to its adherence to principles of "open skies" and "nondiscriminatory data access."

The commercialized remote sensing industry is in its early stages. It has successfully evolved from the 1972 launch of ERTS-1 but it still has a long way to go. The commercial success of the SPOT program is not dependent on Landsat's failure. SPOT program plans, beginning in 1977, always were and still remain based on the existence of a strong Landsat program. In an attempt to establish a multi-billion dollar dustry, multiple commercial sources of data are essential. The expansion of existing applications and the development of new applications are based, to a great extent, on the differences between SPOT and Landsat which make these two data sources complementary.

SPOT Image Corporation looks forward to competing with EOSAT. SPOT's commercial approach is aggressive and entrepreneurial, but at the same time, it is recognized that competition from EOSAT is essential to industry growth. The loss of EOSAT will have a negative influence on the current momentum of the entire industry. It is in everyone's best interest, including SPOT's, for EOSAT to survive. However, SPOT and other U.S. and world corporations are committed to keep this momentum going, and to ensure the success of this important industry.

THE MARKETING CHALLENGE

Marketing of image data is one of the largest challenges to implementing the SPOT program and establishing a successful commercial remote sensing industry. The following six concepts are recognized as cornerstones to SPOT's marketing, and the achievement of these goals.

1. SPOT Image Corporation is working to familiarize users with the new commercial "rules" which govern the availability and use of image data. SPOT has pioneered the

use of licenses and copyrighted data in an attempt to be as flexible as possible in relation to a user's needs, while ensuring that the appropriate revenues are collected by the suppliers of that data. Data costs have risen when compared with costs during remote sensing's research and development phase. However, when viewed in terms of system development, launch, and operational costs, and in terms of the actual value of the data to the user, the current costs are considered to be inexpensive.

2. Industry growth depends on increasing established applications and developing new applications based on SPOT's advanced capabilities: high resolution, rapid revisit and stereoscopic image production. Early results from SPOT's preliminary evaluation program (PEPS) reveal the increased value of SPOT data to applications in cartography, urban planning, forestry, geology, agriculture and several other disciplines. New and expanded applications include news gathering, disaster monitoring, use in terrain simulators, stereoscopic image analysis and terrain modeling.

3. In this beginning period of the newly commercialized remote sensing industry SPOT is working to market the entire remote sensing package, rather than just the image data which are the program's main products. This involves working with all components of the industry, including hardware/software manufacturers and value-added companies, to ensure that the entire technology becomes more affordable, accessible and user-friendly.

4. Many established and new applications rely on obtaining data which are as close to "real time" as possible, particularly in agriculture, disaster monitoring and news media applications. SPOT's one day turnaround of their initial Chernobyl imagery was more the exception than the rule. However, since then, SPOT's turnaround time, from image acquisition to product delivery, is continuing to decrease as the number of receiving stations and data distributors, and the system's image processing capabilities continue to develop.

5. SPOT's several processing levels and data formats are necessary to meet the requirements of a wide variety of applications and hardware/software systems. The types of products and the various processing levels are discussed in the previous section. In addition, other components of the industry are continually exploring new options for image data products, such as optical disks, based on the needs of the developing industry.

6. Central to the SPOT commercial program is the ability to produce imagery on a long-term, reliable basis and continue to implement technological innovations. Current plans call for the launch of a series of 3 additional SPOT satellites to provide a continuous source of data into the next century. While SPOT 1, 2 and 3 are designed to be identical, SPOT 4 will include a number of advanced capabilities beyond those currently available. These capabilities, discussed in the following section, are designed to meet the needs of the global user community and inspire the development of further applications.

SPOT 4: FURTHER INNOVATIONS

The HRV sensors on SPOT 4 will have the additional capability to detect emitted light in the middle infrared band ranging from 1.58 to 1.75 microns. This infrared band is particularly well suited for detecting levels of plant moisture and plant stress, and for performing other vegetation studies.

The 10 and 20 meter resolution data produced by the SPOT 4 HRVs will be coregistered onboard the satellite instead of on the ground during image processing. This is in response to the increasing needs of the cartographic user community which requires higher levels of accuracy for their increasingly sophisticated applications.

SPOT 4 will also carry an additional, self-contained sensor called "Vegetation", the purpose of which is world wide monitoring of the Earth's vegetation and oceans. This new sensor will record light in 5 separate spectral bands. The red, green, near infrared and middle infrared correspond to those of the HRVs and are adapted primarily for land observation. A fifth band, ranging from .43 to .47 microns, was chosen for ocean observation and applications to such fields as marine biology, oceanography, sedimentology.

The Vegetation sensor will have increased radiometric sensitivity, allowing it to detect slight variations in Earth surface characteristics over space and time. This high degree of sensitivity will require 10 bit coding of image data, as opposed to the 8 bit coding currently used.

With a fixed viewing angle extending to 50° on each side of the satellite's axis, this new sensor will image a ground width of 2200 kilometers. Combined with SPOT 4's orbital characteristics, this will result in a very high revisit frequency. At latitudes above 35° all areas can be imaged at least twice per day. Near the equator an image can be acquired of any area on the order of 4 or 5 times per week.

The Vegetation sensor will produce imagery with 1 kilometer resolution for regional studies, or 4 kilometers for analysis of larger areas. The spectral bands and the large scale coverage are designed for worldwide applications such as crop forecasting, deforestation, desertification and other environmental studies.

A number of additional changes to subsystems on the SPOT 4 satellite will increase the overall life expectancy to 4 years. These changes include:

-lowering the average satellite operating temperature,
-providing complete redundancy for onboard computer memory functions,
-incorporating a simpler yet more reliable solar generator,
-increasing the battery capacity to reduce the depth of discharge,
-increasing the reliability for the onboard image chain and payload telemetry system.

CONCLUSION

This is an exciting period of rapid development for the new remote sensing industry. During 1985 the industry produced approximately $100 million worth of business. It is estimated by the Center for Space Policy, Arthur D. Little and others, that by the turn of the century, remote sensing will be a multi-billion dollar industry. The potential of the SPOT satellite system, and the changes that this system is inspiring are just beginning to be realized. With SPOT's long-term program goals, including technical and marketing innovations, industry development and the realization of its benefits will continue well into the next century.

Mr. HALL. Mr. Julyan, thank you very much. We have had our co-chairman, Congressman Scheuer, who is the chairman on Natural Resources, Agricultural Research and Environment. And he's co-chairing—he is the senior member of—not in age, but in time on the Hill—for this committee. And he's been with, I think the Speaker's briefing this morning. We're honored that he would attend.

Let me ask you just a real quick question here. You say over 50 percent of SPOT's revenues, did I understand you to say that, were sold in the United States?

Mr. JULYAN. That is not a past tense. So far our sales in the United States do not represent 50 percent worldwide sales. It is our estimate that sales generated in the United States will fall somewhere between the 40 to 60 percent range, once we've matured the markets.

Mr. HALL. Then that's just based on projections.

Mr. JULYAN. Yes, sir.

Mr. HALL. And what percentage of that would be sold to the United States government?

Mr. JULYAN. In the short term, we would estimate sales to the federal government would be somewhere in the 35 to 45 percent range, falling to and leveling off at approximately 20 percent. But again, what you're getting here with these numbers are—are my best numbers—but these are my forecasted numbers.

Mr. HALL. How is SPOT Image financed, and tell us about the subsidies.

Mr. JULYAN. SPOT IMAGE is a private corporation organized under the laws of France. SPOT Image Corporation, a U.S. corporation is a wholly owned subsidiary. The shareholders of our parent corporation—and I'll be glad to introduce a list of the shareholders with their holdings for the record—

Mr. HALL. They'll be put in the record.

[Information to be furnished follows:]

SPOT IMAGE SHAREHOLDERS AND PERCENTAGE HOLDINGS

CNES	(Centre National d'Etudes Spatiales)	39.0%
IGN	(Institut Géographique National)	10.0%
MATRA		8.8%
SEP	(Société Européenne de Propulsion)	8.8%
BRGM	(Bureau de Recherches Géologiques et Minières)	7.4%
IFP	(Institut Français du Pétrole)	7.4%
ISIS	(Société Internationale de Services Industriels et Scientifiques)	2.6%
IRDI	(Institut Régional de Développement Industriel Midi-Pyrénées)	1.2%
Banque Nationale de Paris		1.2%
Crédit Lyonnais		1.2%
Banque de Paris et des Pays-Bas		1.2%
Valorind (Société Générale)		1.2%
SSC	(Swedish Space Corporation)	6.0%
Belgium State	(Service de la Programmation de la Politique Scientifique)	2.0%
Belgium Companies Belfotop Eurosense S.A. Walphot S.A. BTMC: Bell Telephone Manufacturing Company ETCA: Etudes Techniques et Constructions Aérospatiales)		2.0%
		100.0%

Mr. **JULYAN**. Includes both public and private sector. The single largest shareholder is the French space agency, CNES, with 39 percent. Additional shareholders include both government agencies in France as well as private entities. For example, Matra and SEP, two large aerospace private firms, both own each over 8 percent of SPOT IMAGE.

Financing for SPOT IMAGE has been done, and continues to be done under typical private operations. We received both equity contributions from our shareholders when we initially established the company, in exchange for their shares. And continued financing is done on the basis of revenue and debt, both from our shareholders as well as from outside firms, such as banks.

We do not receive at the parent corporation level an annual subsidy from the French government.

Mr. **HALL**. But you certainly do from the space agency because they're a part of your group, CNES.

Mr. **JULYAN**. We receive from various shareholders, loans. We do not have an annual subsidy. Everything for SPOT IMAGE—and therefore, for SICORP as well—everything that we receive outside of our revenue is either a debt or equity contribution.

Mr. **HALL**. And you have loan commitments from European banks. Are they also members of your group?

Mr. **JULYAN**. I believe the answer is that most of the banks if not all of the banks are members, but there may actually be a few banks that are not members of the group.

Mr. **HALL**. I may have other questions. At this time I recognize the chairman, Mr. Scheuer.

Mr. **SCHEUER**. Thank you, Mr. Chairman. I think we are all as one with you that this is a marvelously interesting field. It will be a multibillion dollar industry in years to come with incredible payoffs for human well being, especially in the developing world, but in our country and other developed countries, too.

I'd like you to elaborate on your statement that SPOT and Landsat compliment each other. Maybe the forthcoming Japanese capability also has some kind of interface with SPOT and Landsat. Give us your feeling about that. And as you project this multibillion market to emerge, tell us how you think the market share will be divided between SPOT, Landsat and the Japanese capability in the 1990s.

Mr. **HALL**. I might say, Mr. Chairman, as you well know, the Japanese were invited to attend here to testify but declined.

Mr. **SCHEUER**. That's regrettable.

Mr. **JULYAN**. To address your first question, Mr. Chairman, the basic characteristics of the sensors being flown on the two satellites are different. SPOT has a 10-meter panchromatic black and white mode which provides nine times greater resolution than was previously available from the Landsat-TM. SPOT also has a 20-meter multispectral mode, which is similar to, but has fewer bands available than the SPOT TM-30 meter resolution.

Landsat's other sensor is the 80-meter ground resolution MSS. Each of these modes provides a balance between spectral information and spatial resolution. They all have a place.

Perhaps the best example of the complementary nature of the two systems is the image of Chernobyl which has recently been released, or I guess now it's not so recent anymore, that combine the SPOT 10-meter panchromatic data to provide the maximum resolution or detail possible with the thematic mapper, the TM of Landsat to provide the multispectral.

It is true we could have done that, or it could have been done with SPOT's 20-meter data. But by doing this and by doing this in the future, some of the information available from Landsat's seven bands of TM can bring out additional information about the impact of that nuclear disaster.

Other areas where we find ourselves complementing include, adding the panchromatic imagery, merging it with TM, like the Chernobyl image in a variety of applications, even geology.

It was stated by the first panel that while these satellites orbit the earth on a continuing basis collecting imagery, a lot of times we find clouds. Those figures that we use are that approximately 15 percent of all images acquired by the satellite; usable being defined as 25 percent or less cloud free. So you can see that a lot of our activity actually goes to taking pictures of clouds.

The same sort of statistics are true for Landsat. So the availability of the basic data from the two instruments, from the two satellites is influenced by—and we obviously get the benefit of having more than one operational bird.

I think the other benefit probably comes not so much from our complementary nature but our ability to compete. Not so much compete in the sense of trying to get the same customer. Yes, we'll do some of that in the future. But more in terms——

Mr. SCHEUER. That's the nature of the system.

Mr. JULYAN. Absolutely. And we make no apologies for our entrepreneurial side or our aggressiveness. But I think that the reality of where this commercialized industry is today is such that you have to recognize—we certainly do—that the presence of a second source of data encourages the development of uses of that data at every point that you may look, whether it be for the venture capitalist who have to make a decision to put equity financing into a new value added firm with a new idea or product, or whether it be an established corporation trying to decide whether to accept this technology as an operational tool.

Certainly one of the questions at the board level or the senior VP or the president level, when a new technology is being introduced and a commitment of at least tens of thousands of dollars, and in many cases, hundreds of thousands of dollars is on the table, where do we get the data from? How many different sources of data are there? These questions have to be answered in the proper way if we're going to expand.

Mr. SCHEUER. Why do they need more than one source of data?

Mr. JULYAN. I would say for two reasons. One, because the difference of the sensors means that—different data sources give you different types of information. And two, you obviously need the protection of not having to depend on a sole source.

Mr. SCHEUER. Now how do you market your service to a potential customer in this country, either the government or private industry? What features do you stress of your service?

What kind of a marketing push do you give them? What's you're zing?

Mr. JULYAN. In the case of SPOT, I think our zing are the following. We emphasize the characteristics of our system, 10 meter data, the fact that with SPOT we have mirrors to both revisit the same area on the earth more frequently than Landsat, and also to create a 3-D or stereoscopic image of the earth.

We also emphasize, and this is certainly something that Landsat as having trouble doing right now, the continuity of our data. The SPOT program has already funded SPOTs 2 and 3. SPOT 4 is in design with new instruments on board. And SPOT 5 is already under consideration. So that when we go to market, in terms of showing who we are, or in this case what we are, we include the continuity of data as a very important item.

The final part of our marketing——

Mr. SCHEUER. We've helped you on that, of course, haven't we?

Mr. JULYAN. In the—because of the——

Mr. SCHEUER. Well, our indecision, our ambivalence, our waffling has given you, I would think, a very compelling, credible market approach.

Mr. JULYAN. I would certainly agree that when SPOT speaks of continuity of data to the turn of the century, we can make that statement. And when the same question is asked at EOSAT today, they obviously have difficulty in answering it.

Mr. SCHEUER. I would think so.

Mr. JULYAN. The last part of our zazz, if you will, is in the commercialized approach. From its conception, we've thought of SPOT Image as a private sector. We market aggressively. We use entrepreneurial techniques. We use the value of the pretty picture of our imagery. We use all the typical and traditional resources of an entrepreneurial activity in terms of our appearances at trade shows, our brochures, our selling of data to the media, et cetera, to try and bring attention to what we are.

The last part of what we do though, and this is probably equally important is, we don't sell just SPOT. We sell the remote sensing industry. That means that in addition to us as a supplier of data, we bring to the table when we talk to a client the reality of the hardware, software systems, the computer systems that are available today to use our imagery, as well as the services of the value added firms that can help either in providing the service directly to an end user, or in giving him the educational curve for adapting that resource for his own use.

Mr. SCHEUER. Mr. Chairman, with your indulgence, I know I've gone a little bit over time, just this last question.

Mr. HALL. You don't ever shut the chairman off.

Mr. SCHEUER. Well we're co-chairmen, but you're in the catbird's seat now.

Have you ever thought of the possibility of conducting a joint venture with EOSAT, or perhaps the Japanese, or perhaps both, all of the above? As we move into the '90s and approach the turn of the century, it's not only a multibillion dollar market, but multi-multibillion dollar investments in this incredibly sophisticated and expensive technology to get that capability up there.

Might it not make sense to share both the technology, the brains and the talent that exists in the United States, France, Japan, perhaps the European Space Agency, sharing not only the talent but of the needed—but get joint production really of the needed capital investment?

Mr. JULYAN. I'd like to answer your question by separating the space segment from the ground segment. With reference to the space segment, the satellites themselves, I'm really not qualified to address that. SPOT-2 has been built, and will be launched as soon as it's necessary to replace SPOT-1. SPOT-3 and 4 have—well, SPOT-3 has already been designed and has already been funded. And the decisions for what sensors will go on SPOT-4 is well underway now.

With that in mind, and certainly up until this point the space segment of our program has always been operated exclusively through the initial and original project.

With reference to joint venturing in terms of the sales and marketing activity, I'd like to say two things. Number one, we do that now in our own way. We in trying to encourage uses of SPOT data will go into arrangements with, not EOSAT but with other members of the remote sensing industry where we work together, we share the risk, in trying to get SPOT data, apply it for a particular application, then see whether or not there's a market for that application. And having shared some of the risks up front, also share in some of the profits down the road.

Mr. SCHEUER. Now who do you do that with now?

Mr. JULYAN. Today we do that with what we call the value added firms, some of the existing sophisticated service companies who have the equipment to take in data and apply it for a particular purpose. I'll give you an example.

Last year there were forest fires in Idaho in August. And I was going out to address the RTNDA, Radio, TV News Directors Association, because we were trying to see whether or not the news media represented a viable market for SPOT data. We knew that to simply go there and try and ask them the question might be difficult. So instead what we decided to do was the following:

The day before I had to give my speech we had SPOT acquire an image of a forest fire taking place in Idaho.

Mr. SCHEUER. Right at that time.

Mr. JULYAN. At that time. We couriered that image to a value added firm in Redding, Massachusetts called TASC. And they, on an overnight basis, at their expense, on their nickel, did what I would estimate to be something in the neighborhood of about $10,000 worth of image enhancement and other type of work to the image. Then shipping it back to me in Salt Lake City on a videocassette.

So when I stood up to address these people about what was this industry all about and did it mean anything to them, we were able to actually show the fire that was still burning in Idaho as an image and say, would it make any sense to you to put this on the news tonight.

Mr. SCHEUER. All I can say is, EOSAT better be on its toes. This is not only zing but sizzle. [Laughter.]

Terrific.

Mr. JULYAN. There is another part of the industry that I call the systems component. Both micro and mini based computers now can take data in and create products. The price of these systems range from $35,000 to half a million or more. We try to work with those companies in terms of identifying how we can present to their clients and to our clients the fact that we are an industry. That it is not just a situation of a government sponsored R&D project that might have applications for them.

Mr. **Scheuer**. If you're an industry, why do you exclude EOSAT as a possible joint venturer?

Mr. **Julyan**. I didn't mean to exclude EOSAT as a possible joint venture in the future, I just meant that we haven't done anything thus far. It is certainly true that the—there's a difference between working with EOSAT or working with the other members of our industry based on the fact that we are the only two suppliers of data.

Mr. **Scheuer**. IN other words, EOSAT is a competitor and those others out there could be possible extension of your capability but aren't directly in competition with you.

Mr. **Julyan**. That's true. And while we would certainly entertain in the area of sales and marketing any proposals that we thought would help advance the industry, we certainly would, without being overly paranoid about it, we certainly would want to make sure that we weren't getting into antitrust problems and that we were not getting into any arrangement that would be in conflict with the basic policy of SPOT.

My mandate, my responsibility as the head of sales and marketing for SPOT is obviously to sell as much SPOT data in the United States as we can. There are certainly ways that I can think of, without giving you details right now, but I can certainly imagine some hypotheticals where by working with EOSAT we could accomplish that goal and not be in conflict, in the areas of sales and marketing.

But I also think it's important to note that the healthy competition of two suppliers of data, I believe, is a fundamental cornerstone in building an industry and getting confidence from the user community.

Mr. **Scheuer**. I agree with you completely, and I hope the competition—the stimulus and the spur of competition will move the EOSAT people to the kind of imaginative and resourceful thrusts and initiatives that you just demonstrated by sending that cassette out there which covered the raging forest fires that were at that time taking place. That was terrific, brilliant.

But I would hate for the antitrust implications to cast a pall over the possibility—and a cloud, a legal cloud over the possibilities of joint venturing and cooperation between you and EOSAT. After all, that law was passed in the 1890s and it hardly contemplated the kind of multibillion dollar investment and the extraordinary amount of talent and capital that could be harnessed in a joint venture, both to the benefit of France, in your case and your investors, and EOSAT, the public and the private investors, too.

So I wonder whether you could perhaps give us a memo of what you think the antitrust impediment might be, how you see that as casting a pall over possible modalities of cooperation, joint venture, call it what you will. And we'll look into that and we'll talk to the Judiciary Committee and perhaps the Justice Department.

We are so eager to get up there in space. And we are, as you well know, in such a time of resource constraints in this country, that anything that would militate against a cost effective sensible level of cooperation with the other major actors in space would be totally counterproductive. And especially if it stems from a law that was passed a century ago almost—within a couple of years of a century ago. And we ought to do what's logical.

So if you could give us the benefit of your thinking on that and submit a brief memo for the record, I would ask unanimous consent, Mr. Chairman, that we hold the record open for 10 or 12 days or two weeks or whatever you would need to get that in. I think that would be extremely helpful for all concerned.

Mr. HALL. Without objection, we will do so.

[Material is available from committee files.]

Mr. JULYAN. Mr. Chairman, I'll be glad to take that back, both to our counsel and also present it to our friends at EOSAT and see if they can't also—might be a good question to start the whole question of antitrust, to see if we can't at least have our lawyers and their lawyers look at it from both perspectives whether or not there are such antitrust problems that would arise.

Mr. SCHEUER. And I'm sure that the chairman would direct our staff to make contact with the EOSAT personnel and ask them to get in touch with you, so that they'll get the message from both ends. I think a joint memo from your counsel and EOSAT's counsel would be extremely helpful to us. And I appreciate your testimony. It really was very thoughtful and very provocative.

Mr. JULYAN. Thank you, Mr. Chairman.

Mr. SCHEUER. I apologize for going over, Mr. Chairman.

Mr. HALL. Thank you, Mr. Chairman. And at this time I'd recognize the gentleman from California, Dr. Packard.

Mr. PACKARD. Thank you very much. Mr. Julyan, do you exchange present data with other SAT institutions, EOSAT and others?

Mr. JULYAN. We have licensed data to EOSAT. We don't sell data, we license its use. But for the purposes of this hearing, without trying to confuse it, I'll just say from now on that we sell it. We've sold data to EOSAT. We have never as SPOT Image Corporation purchased Landsat data ourselves. We don't have that type of function within the company.

Mr. PACKARD. Where do you see SPOT going in the future? What are your goals and the goals of your company in terms of the world marketplace, et cetera?

Mr. JULYAN. Let me try and answer that again with the differentiation between the space platforms and the sales and marketing activity. Speaking first of the satellites, SPOT-2 and -3 will be identical to SPOT-1, meaning that the 20-meter multispectral and the 10-meter panchromatic will be the modes operating on the satellite.

SPOT-4 will be the first satellite of the series that will have slightly different or additional sensors. We're adding another multispectral band, and we're also putting in a new sensor, something we call a vegetation sensor, a piggyback sensor. This is designed for collecting much coarser resolution, a kilometer versus 10 meters, but being able to provide data on a very regular and routine basis covering the whole world.

The vegetation sensor is obviously being added to the satellite because we do consider the non-renewable and the agribusiness marketplace to be a very significant part of our future, even though it has not been a significant, or as significant a part of the past marketing.

Additional characteristics of SPOT-4 will include on board merging of the 10 meter and 20 meter data. I spoke of the merging of the SPOT 10 meter and the Landsat-TM in the case of Chernobyl. We found just in our own sales activity thus far that putting the two data sets together even just from SPOT is a very valuable and a very interesting product. So we'll merge on board the spacecraft with SPOT-4.

Finally, there will be some differences in the satellite itself designed to extend the life of the satellite.

On the ground we see the following. The heavy influence of the past has been with sales made to the federal government, the defense community within the federal government, the oil and gas industry. In the future, each one of those areas will probably diminish as a percentage of our future sales. We see future sales coming from the renewable resource industry, land use in urban planning, cartography—especially important to us—and hopefully some new markets.

The experiment, if you will, is still on for us to determine whether or not the news media is a viable market for SPOT data. They are certainly interested in being able to look from space. They are certainly interested in being able to get the data delivered from a commercial vendor. If it is a new market, by the way, it should be a SPOT market. And I say that not as a reflection of, in any way EOSAT's marketing, but simply as a reflection of—and going back to the comments about what are the differences between the satellites—10 meter data for news application is probably more significant than 30 meter data.

But we don't know yet if the news media will be a viable market. We'll try to answer that question in the next couple of years or in the next couple of months—from the pressure that I get from my president and the board of directors—and we're trying. You'll see more evidence of that very soon.

Mr. PACKARD. Will the launch schedules affect your timetable as you move into the areas you've spoken of, the ability to launch? Obviously the cutback in the U.S. schedule may put pressure on the area on schedule. Is that going to affect your timetable?

Mr. JULYAN. It could. We do launch the SPOT satellites with Arian launchers.

Mr. PACKARD. Exclusively?

Mr. JULYAN. Exclusively. The launch of SPOT-2 will not take place until SPOT-1 needs to be replaced. The satellite itself has behaved extremely well since launch. We did suffer the loss of one of two on board tape recorders, but that's been the only significant problem we've had with the bird thus far.

The other characteristics that define the life of a satellite, the operating temperature, the batteries, on board fuel, all of these parameters are above specification now. So that we now estimate that pending any unforeseen circumstances, SPOT-1 rather than a two to three year nominal life, now is expected to have a three to four year nominal life.

Mr. PACKARD. Will it require a new satellite to accomplish some of the goals that you've outlined, or can the existing satellite perform those functions?

Mr. JULYAN. The existing satellite can perform the functions in some ways as soon as the sales and marketing effort and the production effort catches up with it. By that I mean the following.

Some critical markets, the news media and agribusiness are interested in and can use the data that comes down from the SPOT-1 satellite. However, successful and maximum penetration of those markets can only be accomplished when the turn around time from acquisition of the data to delivery of the data is measured in days not weeks. Although we can make data available from the United States out of our Reston archive to users within days, from time of acquisition to time of actual delivery of data, especially in the case of non-U.S. sites, we measure that in weeks still.

So these markets won't be available to us until we can improve that. That's something we can control and we can accomplish with the on board—with the current satellite. The vegetation sensor in SPOT-4 will clearly open up new opportunities and new markets that are not available with the sensors flying in SPOT-1 through -3.

Mr. PACKARD. How much new research is SPOT involved in? And where is the source of—the primary sources of your information? Are you doing most of your own research? And is the company involved a great deal in research?

Mr. JULYAN. The research that we do in our market research, for example, out of Reston is done in Reston with our existing staff and in cooperation with some of the other participants in the remote sensing industry.

The research and the development of the news sensors and the new technology that goes on the spacecraft is coordinated and handled out of the French space agency, CNES located in Toulouse.

Mr. PACKARD. What is your—do you feel that it would be advantageous for EOSAT to become more privatized and separate itself from government funding? Would that assist them in moving more into the commercial market?

Mr. JULYAN. I don't think I can address your question directly, just because of my perspective. But I would like to say this, in trying to move this technology from the public sector to the private sector, there is clearly a role for governments to play, especially during this transition period.

Eventually the success of our industry is going to be directed by and led by private firms. I believe that SPOT Image and SPOT Image Corporation have already shown that this can be done. I believe that the existing value added firms that have evolved over the last 15 years of the availability of Landsat data represent transitions. Many of these are private firms, but are largely dependent on, and get most of their revenue from their work for the government.

So that some of the perspectives, some of the mentality is not so much what I would call entrepreneurial as it is dealing with the government. We can sell to the government, we can make money from the government, that's fine. But I think we've also got to really look at this as new products, new ideas to reach these other marketplaces.

Mr. PACKARD. On the short term then you still see the government as being the primary marketplace for the data? On the longer term you're seeing it expand out into a variety of areas?

Mr. JULYAN. I'd agree with that, yes.

Mr. PACKARD. Mr. Chairman, thank you very much.

Mr. HALL. Thank you. The chair recognizes the gentleman from Iowa, Mr. Stallings.

Mr. STALLINGS. Thank you, Mr. Chairman. I was very impressed with your statements, Mr. Julyan. It's an amazing world that we're living in today.

I was just looking through this 1987 edition of Soviet military power and I find a couple of your photographs in here. Also in a recent newspaper report from the Washington Times, the 21st of March, "Multimillion dollar negotiations for a steady supply to SPOT's photographs are being conducted by the Defense Mapping Agency."

Is this press report of your discussions with DOD accurate?

Mr. JULYAN. My hesitation, Congressman, is because we have a policy which is very important to us to keep all of our client contact and client information confidential. We do that, by the way—and then I'll try and give you as close to an answer as I can—we do that because we consider this confidentiality to be critical to our success, and because we recognize it as an important part of the difference between SPOT Image Corporation and SPOT IMAGE in France.

For example, when U.S. clients purchase data from our company in Reston, our parent does not know—and it is written in our contract with the parent that we cannot provide them with any client information in terms of who's interested in which sites.

Having said that, there's nothing in that article that I would disagree with, but I would certainly direct the congressman and the committee's attention to the appropriate federal agencies to ask them since they probably would have to give you a more direct answer.

Mr. STALLINGS. My other question is along the same line. The current volume of SPOT data sales to DOD, is that—I guess to get that information we'd have to go through Defense also?

Mr. JULYAN. I'd respectfully ask you to do that, sir.

Mr. STALLINGS. Let me ask you a similar question then. Are you selling photographs to the Soviets?

Mr. JULYAN. SPOT Image Corporation in Reston, Virginia does not provide data to anyone outside the United States. Specifically to your question, SPOT Image Corporation does not sell data to the Soviets.

However, I want to be clear that SPOT Image operates out of Toulouse, France with open sky, open access policy. And therefore, if a Soviet citizen were to come, either to SPOT Image in Toulouse or to a distributor of our data and request any imagery which we have acquired, that imagery would be made available.

Mr. STALLINGS. Thank you, Mr. Chairman.

Mr. **Hall**. Thank you. And thank you, Mr. Julyan. Appreciate your time.

Mr. **Julyan**. Thank you very much, Mr. Chairman.

Mr. **Hall**. And certainly your printed remarks will be made available to the other members of the two subcommittees, and the full committee.

Mr. **Julyan**. Thank you.

Mr. **Hall**. All right, at this time we'd ask for the next panel. I think we've heard from some conventional users, oil, gas, states. This panel has, I think some unconventional or very novel users, media, environmental groups. And we can get underway here with Mark Brender of ABC-TV News here in Washington. And I believe Greg Koeln of Ducks Unlimited is to be here.

Mark, we might tell you that we have a notation from President Reagan here that he'd like for Sam Donaldson to be given a seat on the next launch. [Laughter.]

Mr. **Brender**. I'm Sam Donaldson editor. I would like to see him on that next launch, too. [Laughter.]

Mr. **Hall**. Well, you've written part of my script for me here, and I was just trying to carry it out.

All right, we'd ask you—you've been here. We have given other panelists five minutes to summarize and they've taken 20. Stay as close to a five- or six- or seven-minute summary as you can. And we recognize Mr. Brender at this time.

STATEMENTS OF MARK E. BRENDER, ABC-TV NEWS, WASHINGTON, DC; AND GREG KOELN, DUCKS UNLIMITED, LONG GROVE, IL

Mr. **Brender**. Mr. Chairman, Mr. Chairman, thank you. I'm Mark Brender from ABC News, and I'm a non-traditional user. And I don't care about clay and I don't care about silicates, and I don't care about EEZs. I care about news. And I could take you for a moment over that horizon behind you and we can take a quick look into the future of where newsgathering is going.

Congress decided in 1984 that it's in the national interest to establish a viable commercial remote sensing industry. And the Administration on several occasions has mentioned the importance of commercializing space. And EOSAT is a centerpiece of those policies. EOSAT is a vehicle by which those policies now can be enunciated.

The media is becoming an increasingly important user of remote sensing imagery. Probably the first time, the most important time was during the Chernobyl incident. For three days the world did not know what was going on. They could not see with their own eyes what was happening. It was first Landsat and then it was the SPOT satellite that provided the west with the first images of what was going on there.

With those images we were able to pierce that veil of Soviet secrecy that surrounded Chernobyl. And who knows, possibly is was the publication of the image of Chernobyl that appeared on all the networks for days running and around the world in newspapers that might have forced the Soviets to be more forthcoming more quickly on the issue.

And we've used it at ABC many more times than that. In fact time on World News Tonight we should use some imagery provided to take a look at some aspects of the Soviet Union. This is barring any unforeseen news that's going on right now that I don't know about. But we plan to run a piece tonight to show the west, the public, the first look at the Soviet radar facility at Krasnoyarsk in the Soviet Union. I ask the chairman, have you ever seen Krasnoyarsk? Is it a violation of the ABM treaty? Does it even exist?

Well, the media now is independently verifying Krasnoyarsk and we may conclude tonight that it is in fact a violation of the ABM treaty. Again, I caveat that, we plan to use it tonight, and things do change in my business minute by minute.

EOSAT is important for imagery for us, but also for a lot of other reasons. It preserves the price and serves as competition among vendors. A strong commercial remote sensing system will provide an important background for commercial R&D in this sense. You don't want to have the government doing commercial R&D all the time, but with a fully funded EOSAT, a viable commercial R&D and value added industry will remain strong in this country.

And a commercial remote sensing industry will enable to keep the vitality of the open skies policy established in the mid-'50s under Eisenhower as a viable entity around the world. It's very hard for a diplomat to stand up at the U.N. or in other world bodies and talk about open skies and the importance of freedom of information around the world when they don't even have a satellite up there, or the industry is dying in this country. You lose credibility, and our competitors in other markets will end up moving ahead.

The media is beginning to look now at the feasibility of a high resolution Mediasat, a three to five meter—probably five meter—near real time system that will give us a capability to look anywhere around the world. We're living in an information environment. We're living in an information era We've moved from the industrial revolution to the information revolution where information in and of itself has value. And as a newsgathering organization, as an information organization which we are, we could sell that.

And we can look around the world to see what is happening. We can look at the townships in South Africa. I ask you, Mr. Chairman, what's going on in those townships now? We've been excluded from those townships. We'd be able to see from space generally what's going on. What is the U.S. doing along the Nicaraguan-Honduran border? What's the infrastructure that's been built up? What's going on in the Iran-Iraq war right now? Here's one of the bloodiest wars in a long time, has a tremendous impact on oil prices, and a tremendous impact on the geopolitical structure of the Middle East. Who's winning? No one knows.

Now at budget time we'll be leaked certain things when the government wants us to put something on the air and we're manipulated. And Iraq will call up and they will say, the Iranian missile attack on our oil field never happened. And Iran will call me up and they'll tell me that it did happen. Well, there's a picture of an

Iraqi oil field with smoke plumes coming out of it. This is the truth.

And I'll close now. The Landsat Act also—right now NOAA is setting up the final rules and regulations for the Landsat Act, and those will be published soon. We have gone in, the Radio-Television News Directors Association, NBC News, Turner Broadcasting, National Association of Broadcasters and many other trade associations are expressing our concern about these rules. That they're not going to give us the flexibility.

The First Amendment, it appears, will not go up into orbit. And the government says, welcome to space, but we want it on our terms. The Pentagon has said in a letter of January 22, that, sure, welcome to space, news media, but we want to give the Secretary of Defense maximum discretion, flexibility and the right to deny access. Well, gentlemen, those are buzzwords for censorship.

And finally, EOSAT funding will pave the way for follow-on systems, and as I said, research and development. And without it the road will be paved overseas to competitors and we're going to be losing a most important edge in an information era, and a most important information gathering tool for this country. And just when remote sensing is about to come out of the closet into the information era, the government is going to slam the door on it.

Thank you.

[The prepared statement of Mr. Brender follows:]

Testimony of Mark E. Brender
Chairman, Media In Space Committee
Radio-Television News Directors Association

Before the Subcommittee on Natural Resources,
Agriculture Research and Environment,
and the Subcommittee on International
Scientific Cooperation of the House
Committee on Science, Space and Technology
April 2, 1987

My name is Mark Brender. I am an assignment editor at ABC News, and the Chairman of the Media In Space Committee of the Radio-Television News Directors Association. I also head an industry-wide task force on media remote sensing.

The news media have become increasingly important users of commercial remote-sensing imagery over the last two years. That development can be traced to the Landsat Act, which this Committee proposed and which Congress adopted in 1984. Today, EOSAT is the centerpiece of the Landsat Act. By placing the Landsat program in private hands, Congress's goal was nothing less than to midwife the birth of a viable commercial remote-sensing industry.

Without remote-sensing satellites of their own, the media rely heavily upon EOSAT and Spot Image for the imagery which is fast becoming an integral part of the news business. The best example is Chernobyl. When the partial meltdown of the Chernobyl nuclear reactors occurred last spring, no one knew what had happened or what the consequences would be. It was the imagery produced by commercial remote-sensing satellites -- first EOSAT's Landsat 5 satellite, and then the Spot 1 satellite -- that pierced the veil of Soviet secrecy surrounding the accident.

The Chernobyl imagery was broadcast on all four major networks in the United States, and it was published in major newspapers around the world. It was the watershed in the media's use of remote-sensing imagery, and it opened the eyes of the media to the unique contributions that remote-sensing imagery can make as an information resource to the business of gathering and reporting the news.

EOSAT is important not only for supplying the imagery used by the press, but also for preserving price and service competition among vendors of remote-sensing imagery. Without that competition, the media would be dependent upon primarily one supplier of imagery for the foreseeable future. EOSAT represents probably the only commercial entity in the United States that can realistically be expected to operate a remote-sensing system during the next several years.

The media are just now beginning to explore the possibility of joining EOSAT and Spot Image as suppliers of remote-sensing imagery. As our experience with imagery has grown, we have begun to define more precisely the requirements for "media-ready imagery." For imagery to be widely recognizable to the public, it must have high resolution on the order of 3 to 5 meters. For imagery to be integrated into the day-to-day business of reporting the news, it must be obtained in a timely manner to meet publishing and broadcasting deadlines. Not all remote-sensing customers want this type of imagery, but the media do. Those two attributes, and particularly 3 to 5 meter imagery, are the hallmarks of remote-sensing journalism.

Title IV of the Landsat Act clears the way for news organizations to pursue the option of building, launching and operating their own remote-sensing satellite, what we call a Mediasat. Yet NOAA is considering adopting remote-sensing regulations that could remove the media's incentives to seize the opportunity Congress has provided. The regulations proposed by NOAA could be interpreted to give the Departments of Defense and State a virtual carte blanche to impose ad hoc restrictions on media remote sensing -- now and in the future -- under the easily-manipulated rubric of national security and foreign policy.

The "chilling effect" of that policy is obvious. No news organization, or consortium of news organizations, would be willing to invest the millions of dollars necessary to establish a Mediasat without some assurance that the system can be used for its intended purposes.

The media have no desire to compromise our country's national security and foreign policy. The press has a long history of reporting the news without violating vital national interests, and we stand on that track record. All we ask is that our freedoms guaranteed by the First Amendment to the United States Constitution be respected. Both through its Media In Space Committee, and as a leader in an industry-wide task force on media remote-sensing, RTNDA has worked long and hard to protect those freedoms which are an essential part of any effort to get the Mediasat concept off the drawing board.

There are a multiplicity of options for placing a sensor into orbit for the media, but those options may never be fully explored if the media do not receive assurances that the First Amendment will accompany that sensor into space. Of course, it will be years before a Mediasat could become a reality. That makes it even more imperative to ensure that EOSAT continues to be a viable competitor in the remote-sensing industry.

EOSAT and Mediasat share a common goal -- to establish a significant United States presence in the commercial remote-sensing industry. Without that presence, the United States would relinquish its leadership position in the industry to foreign interests, a leadership position it took fourteen years and millions of taxpayer dollars to build. Our very competitiveness in the growing international industry of commercial remote sensing will be jeopardized by any governmental indecisiveness regarding the policies necessary to assure full participation by the private sector in the national policy to open up outer space for commercial purposes. And EOSAT is central to the continued vitality of the "open skies" policy first enunciated by the Eisenhower Administration in the mid-1950's.

The stakes in this international competition are not small. Experts have estimated that the private-sector remote-sensing industry could achieve annual revenues of two to three billion dollars by the year 2000. No one can really doubt that remote sensing is a unique information resource that is being dramatically underutilized at present, and RTNDA believes that Congress should fully support the efforts necessary to tap that resource for the benefit of the American public.

Mr. HALL. Thank you, Mr. Brender. Recognize Dr. Koeln.

Mr. KOELN. Thank you very much. I appreciate the opportunity to speak in front of you, Mr. Chairmen, and the rest of your committees.

I'm Greg Koeln and I represent Ducks Unlimited. Ducks Unlimited is a wetland conservation organization with about 600,000 members. Since 1937 we've expended over $350 million on the preservation, enhancement and protection of wetlands. Since 1937 we've been looking for a way of being able to inventory the declining wetlands in North America. We found a tool to be able to do that. Landsat's Thematic Mapper has been able to provide us with the tool to do that.

I'm representing our corporation, discussing with you our interest in maintaining that tool. But I'm also representing many other potential users from conservation organizations that can and will be using the Landsat tool, but will not be able to do so unless they feel that their investments—their investments in the qualified people, their investments in the capital needed to process the data will be secure. We need to continue the system.

And finally I've been asked to actually demonstrate to you the type of things that we have been doing with the Landsat data in our efforts to preserve wetlands throughout North America. I'm going to do with a series of visuals. I think you can see them well from your seats. The people in back of my obviously will not be able to see them.

But we are inventorying wetlands across the primary waterfowl production areas in North America. It's a 350,000 square mile area, Manitoba, Saskatchewan, Alberta, Montana, the Dakotas and Minnesota. It's on this area that over—covers about 10 percent of the waterfowl breeding habitat, but indeed 50 percent of the North American waterfowl breed. It takes 60 separate Landsat scenes to cover that image. This scene, each one of these rectangles show you the spots that we've already purchased satellite scenes.

We acquire the satellite scene—and this just an example of the satellite scene that we acquire—on magnetic tape for eight million acres. It takes 60 of these separate scenes to cover our study area. Each one of the small yellow blocks here represents one map sheet. And that's basically the unit that our field biologist take into the field. A map sheet covers 33,000 acres. There's 250 map sheets of information available from every TM scene.

We'll produce many different color products, but color products are not our final product. We heard earlier that some people said that TM data was used for mapping. We're not using TM data for mapping, we're using TM data for information gathering. This is a type of map though that can be produced. More importantly though is the type of statistics that we're getting from the data bases.

This is that same map, Burlake, North Dakota in which—in literally just a couple days processing over that whole TM scene we're able to extract that there's 889 wetlands on that map area. The majority of those wetlands are less than two acres in size.

So we come up with the statistics on there. On that particular map sheet, over one-tenth of the study area, or one-tenth of the area on the map sheet is on wetlands. More importantly though, of those 889 wetlands on that map sheet, we have individual statistics for each one of the wetlands. We can tell that on this particular wetland, that is a wetland of 41 acres of open water, 38 acres of deep water, shallow marsh of 29 acres. It's 2.8 miles around the perimeter.

We use that type of information to guide our corporation on where we're going to be spending our money for the enhancements of wetlands for waterfowl.

Another example, this is a Canadian map sheet. Two-thirds of our maps are produced for Canada, and two-thirds of our processing. Standard published map from 1970, overlaid with the Landsat classification wetlands from the 1985, overlaid with a map base and identifier. Every one of the 8,000 wetlands on that map sheet have been identified and computer statistics for the wetlands been produced. We produce that type of information in less than a two week period.

We cannot produce—we've looked at all other types of technique for producing this information for gearing our conservation efforts and have found no other alternative approach. We have SPOT data. We feel that SPOT data will be very helpful in the future. It's helpful now. It is more expensive for our corporation, but also it lacks the mid-infrared data that indeed the TM data has.

Most of the wetland basins are very, very small, often less than a foot in depth. The mid-infrared bands are very crucial for us to utilize.

It's becoming very clear that the only feasible way for monitoring major conservation programs such as the Conservation Reserve Program, the swampbuster, the sodbuster, and the proposed North American Waterfowl Management Plan is through the use of TM data. There's a tremendous potential for number of users, such as Ducks, Unlimited. But few will take the risk for capital investments until we have a future in the Landsat system.

Thank you very much.

Mr. HALL. Thank you, Dr. Koeln.

[The prepared statement of Dr. Koeln follows:]

STATEMENT BY

GREGORY T. KOELN
DUCKS UNLIMITED, INC.
ONE WATERFOWL WAY
LONG GROVE, ILLINOIS 60047-0216

BEFORE

THE SUBCOMMITEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT AND THE
SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION

ON

APRIL 2, 1987

DUCKS UNLIMITED'S USES OF LANDSAT THEMATIC MAPPER DATA FOR THE INVENTORY OF WETLANDS IN THE NORTHERN PRAIRIES OF THE UNITED STATES AND CANADA

Ducks Unlimited (DU) is using Landsat Thematic Mapper (TM) data for generating detailed information on nearly 12 million wetland basins in Canada and the U.S. which are critical for waterfowl production and valuable to many other species of wildlife. DU, working with NASA, has developed space-age technology using Landsat Thematic Mapper (TM) data to produce accurate inventories of wetlands over large regions. With the signing of the North American Waterfowl Management Plan in 1986 by Canada and the U.S., the early completion of an inventory of these wetlands is essential for the successful implemenation of a plan to preserve and enhance wetlands occurring on the Primary Waterfowl Production Areas of Canada and the U.S. The demands for wetland information produced by DU from TM digital data exceed our current computer and staff capabilities. Because of the uncertain future of the Landsat programs, DU has not been willing to expand the program. This uncertain future of the Landsat program has been a detriment to the successful commercialization of Landsat. Many natural resource agencies would adopt similar procedures developed by DU, but fear that the capital investments required would be wasted if the Landsat program is not continued.

WHY INVENTORY WETLANDS?

The United States Fish and Wildlife Service has estimated that over 200 million acres of wetlands existed in the contiguous United States in the late 1700's. By 1980, less than 100 million acres still remained, with annual losses placed at over 450,000 acres per year. Similar losses are occurring in Canada. Since waterfowl populations across North America depend on wetlands for their breeding habitat, and because wetlands have numerous other values to society (it is well recognized that each wetland acre is worth $50,000 in various services to society), it's critical that an accurate inventory of these acreages be incorporated with ongoing conservation programs.

Ducks Unlimited, an international conservation organization, has undertaken a large-scale assessment of these valuable wildlife habitats using Landsat's Thematic Mapper.

STUDY AREA

The area under study is known as the northern prairie, or Great Plains, and extends from South Dakota northward to the boreal forests of Saskatchewan and Alberta. Approximately 900,000 square kilometers of grasslands and parklands are within this region. Glacial activity has left many (approximately 10 million) depressions of varying size, depth and distribution across the area, of which 1.5 to 6 million of these "potholes" commonly hold water in the late spring.

The number of wet potholes varies according to seasonal precipitation levels, as does the length of time the potholes retain their water supply. By July of a typical year, as few as a million may still contain water.

DU refers to this area as the Primary Waterfowl Production Area for North America, because in a typical year about 50 percent of all duck pairs breed in this region. Since this region comprises only 10 percent of the entire waterfowl breeding range for North America, accurate assessments of the habitat become all the more important. TM coverage of the region requires approximately 60 scenes, with each scene encompassing about 3.2 million hectares.

DU'S WETLAND INVENTORY PRODUCTS

The standard wetland inventory from the TM data include reconnaissance maps, wetland classification maps, wetland basin identification maps, and wetland statistics summary reports. The data can be registered to any map projection or coordinate system and can be plotted as map overlays at any scale, although the 1:24,000 U.S. and 1:50,000 Canadian map scales are the most frequently used. Reconnaissance maps are produced from the TM Band 5 data and aid in delineating wetlands, croplands and various other land cover types. The wetland types currently being surveyed are open water, deep marsh, and shallow marsh. Deep marsh is basically defined as emergent wetland vegetation growing in one foot or more of water, while vegetation in a shallow marsh commonly grows in less than one foot of water.

Summary reports are also generated for each wetland classification map. For each wetland the total acres, acres of individual wetland type, the northwest Universal Transverse Mercator coordinate (a worldwide common map reference system), the wetland perimeter value and the basin shape index are recorded.

These parameters are readily obtained by computer processing the TM data. Costs of acquiring this information by conventional methods of aerial photographs, manual interpretation, map drafting, and digitizing is cost prohibitive for our corporation.

USES OF WETLAND INVENTORIES

DU needs timely habitat information for many reasons, including: (1) identifying critical wetlands for waterfowl production, (2) selecting optimum sites for habitat enhancement projects, (3) monitoring habitat losses, (4) monitoring habitat changes caused by droughts and other causes, and (5) improving waterfowl production estimates by including habitat availability factors. To acquire this information by conventional methods, using aerial photography and ground reconnaissance, is very expensive and time-consuming.

DU will use the output products of this study to plan, organize, and perform cost/benefit analyses of efforts for wetland conservation and enhancement throughout the Primary Waterfowl Production Area. A working knowledge of the distribution, abundance, and quality of the wetlands will enable DU to plan manpower, equipment, and funding needs for wetlands protection and enhancement in specific priority areas. DU intends to further expand their use of TM data by updating current inventories to measure rates of change, and also to identify areas most prone to change. Landsat Thematic Mapper data is the logical choice for wide-area, in-depth and accurate assessment of a habitat so critical to wildlife survival.

COST OF DEVELOPMENT

Seeking an efficient and effective tool for monitoring wetlands, DU provides NASA's Earth Resources Laboratory nearly $225,000 to determine the feasibility of using TM data for the inventory of wetlands. NASA's findings concluded that TM data did provide a feasible means to inventory and monitor wetlands. Upon completion of NASA's investigation in behalf of DU, DU invested over $700,000 in computer hardware and hired five remote sensing specialists. DU annually spends over $600,000 to process TM data into information on wetlands. DU did not commit to these expenditures until we were assured that Landsat had a future, when Congress passed the Land Remote Sensing Commercialization Act of 1984. The future of Landsat is now in question.

LIMITATIONS FOR WETLAND INVENTORIES

The single, largest limitation of using TM data for wetland inventories is the availability of cloud-free data. Wetlands cannot be detected from TM data if blocked by clouds or the shadows cast by clouds. DU requires TM data collected in May and July. With Landsat's repeat orbit of 16 days, only two opportunities are available to collect cloud-free images in May and only two opportunities exist in July. If clouds are present on the days the satellite passes over the area, collection of data may be delayed by months or years.

LIMITATIONS FOR COMMERCIALIZATION

Since 1985, DU has purchased over $300,000 of TM data and plans to purchase 40 to 50 scenes per year. DU would like to expand our program, but cannot take on the risk of further capital expenditures until the future of Landsat is settled. Various natural resource agencies have visited our image processing facilities and have inquired as to developing similar image processing facilities in their agencies. Considering the uncertainty of the Landsat program, DU has not advised these agencies to acquire the computer and personnel required to fully process the TM data. Commercialization will only be successful when the existing and potential user community is assured that their extensive investments will not be wasted.

POTENTIALS FOR ADDITIONAL USES OF LANDSAT

Interest in and enthusiasm for DU's use of Landsat's TM data for habitat inventories continue to grow. During 1986, workshops and seminars were given to many groups, including ELAS Users Group, NASA, EOSAT, American Association of Geographers, DU Canada provincial biologists, Canadian Wildlife Service, Saskatchewan Water Corporation, Saskatchewan Research Council, Saskatchewan Parks and Renewable Resources, and Alberta Parks and Wildlife. Three technical papers were presented at a remote sensing conference and an international wetlands conference. A half-hour TV show, WESTLAND, for Canada's public television network, was filmed in Vancouver. In February of 1987, DU sponsored a two-day workshop on DU's use of Landsat data for the U.S. Fish and Wildlife Service.

In March of 1987, DU and EOSAT sponsored at the North American Wildlife and Natural Resources Conference in Quebec City, demonstrations of the uses of TM data for wetland inventories. The demonstrations were well attended by Canadian, U.S., and Mexican officials. The Director General of Flora and the Director General of Fauna for Mexico attended these demonstrations and are seeking DU's assistance in providing analyses of TM data for wetlands in Mexico.

It is becoming very clear that the only feasible way of monitoring major conservation programs such as the Conservation Reserve Program, Swamp Buster, and Sod Buster, and the proposed North American Waterfowl Management Plan, is through the use of TM data. There is a tremendous potential number of users of TM data, but few will risk the capital investment until the future of Landsat is determined.

I guess, and thank you for your fine preparation there.

Mr. Brender, let me ask you a question. I guess all of us, in our background, have felt the frustration that you and the media feel when you try to get information to relay. I practiced damage suit law and I always represented plaintiffs and my doctor always testified that they were total and permanent. The insurance company doctor always testified if a man had a leg off, it might grow back. So you get frustrated.

In carrier warfare in the Pacific, I was a pilot in the ready room, they'd tell us their anti-aircraft couldn't hit us, but up on the carrier deck, they were telling them theirs couldn't miss. So this committee understands.

But let me ask you, what is the legitimate national security limitation—I know that's a broad question, but—that ought to be placed on remote sensing satellite data that you obviously want, and would be very helpful to the American people and the viewing public in understanding situations like Iran, Iraq, the Chernobyl? Just in a couple of minutes, if you can, what are your feelings and the feelings of your profession on that?

Mr. **Brender**. How far do you go? It is my understanding there is a 1978 classified national security directive by Carter, President Carter, that sets ten limits as the barrier line, the threshold, if you will, of what is acceptable and unacceptable to the government.

Initially, when the first weather satellite went up, the Tyro satellite, in the 1960s, the Pentagon tried to restrict the data because in one particular scene you could see Patuxent Naval Air Station as a little white dot and there were national security fears about it. When John Young flew in the shuttle and snapped some pictures with a hand-held camera over Moscow on one of the shuttle flights, with a 70-millimeter lens, NASA wanted the data restricted for national security reasons.

When I was involved in the journalism in space project, NASA wanted certain areas of the earth classified so that journalists could not take a picture, from orbit, of certain areas of the earth. When I responded that you can't classify earth, they backed off.

But there are legitimate national security concerns, and just like there are today, the press very responsibly deals with the governments and the government, when those things come up. I knew about Grenada the day before. We knew about the attack on Libya hours, like seven hours, before. That's why when the attack actually happened at seven o'clock in the evening, you could actually hear it because we had already arranged for phone lines and everything else to have happened.

And we knew that there was a TWA hostage crisis, there was a gentleman on board who worked for the National Security Agency, and we did not talk about that. So there is legitimate prior restraint that we self-imposed ourself and, after all, there's no way that the media—we would say, at ABC News, that the U.S. is going to invade tomorrow Grenada and then American men and women get killed and it rests on our shoulder.

Mr. **Hall**. There's really more cooperation between the media and the State Department and our government than people believe or are led to believe?

Mr. **Brender**. There's much more than you realize. That's correct. But there are legitimate national security concerns that this sort of system raises just like in the 1430s when a guy named Gutenberg invented the printing press. There were the concerns by the government then of by God, what's going to happen with all these people being able to read.

So we have to kind of disengage what our national security fears are and look at this as just information, information that can be used for the public good and it can be projected through the public through the news media. And as I said, tonight you'll see a good example of how we're going to do that.

Mr. **Hall**. I recognize Chairman Scheuer.

Mr. **McCurdy**. Would the gentleman yield for just a minute? I apologize again, but I wanted to report to the committee and let other people know that in the Armed Services Committee we just approved an amendment in our markup which would include funds for Landsat out of DOD for both Fiscal Year 1988 and 1989 and I think it's $25 million for 1988 and $45 million for 1989 and it probably will not be the final product, but I think it's important that we send signals to the Department of Defense, as we do in other areas, that they should be participating in this program.

It passed unanimously in the subcommittee.

[Copy of amendment follows:]

McCurdy Amendment to R&D Authorization Fiscal Year 1988-89 (DOD)

(ADOPTED BY UNANIMOUS VOICE VOTE ON APRIL 2, 1987)

Add to Secretary Latham's CCCI (budget) for FY 1988 and FY 1989 the sums $25 million and $45 million for Landsat data acquisition and development of Landsat satellites 6 and 7 (including launch costs).

Mr. **Hall**. We certainly thank the gentleman for that and we're glad we excused you. [Laughter.]

Mr. **McCurdy**. And I have to go back to make sure it stays.

Mr. **Hall**. We do thank you.

Chairman Scheuer.

Mr. **Scheuer**. Thank you very much, Mr. Chairman.

Dr. Koeln, I must say, your presentation was very inspiring and it just dramatizes the incredible potential of this whole imagery process for improvement of mankind's lot. We're doing the same thing, the same kind of environment monitoring, agricultural crop monitoring about 130 Third World countries through not only Landsat but through our weather satellite. And giving these developing world countries, in Asia, Africa, and Latin America, knowledge of just the kind of conditions you talk about, that helps them decide what to plant, when to plant it, when to irrigate, when to fertilize, when to harvest. Let them know about crop blight, desertification, deforestation.

It's an unbelievably potent tool for bettering the human condition and I congratulate you on the initiatives that your private non-profit corporation has taken. It's a wonderful harbinger of things to come, very, very interesting.

Mr. Brender, yes, I was very much interested in your testimony. You're a brilliant guy. I noticed you talked about a certain degree of military security stamp as a buzz words for censorship. You used the expression buzz words for censorship. Would you just elaborate on that, because we're all concerned with censorship. We want the media to have a full advantage of First Amendment rights and so forth.

Tell us your perception of the danger that's looming up.

Mr. **BRENDER**. The Radio-Television News Directors Association has formed, two years ago, which I formed in 1985, a Radio-Television News Directors Association Remote Sensing Task Force and we have had a dialogue with the government for almost two years now, in trying to influence the Landsat Act.

Mr. **SCHEUER**. What task force was that?

Mr. **BRENDER**. This is the Radio-Television News Directors Association, RTNDA, Remote Sensing Task Force. And on the task force are representatives from the National Association of Broadcasters, the American Society of Newspaper Editors, the American Society of Newspapers Publishers, the nets, and it's like a regular alphabet soup of different people.

We wanted to make sure that when those sensors go up into orbit, that the First Amendment goes with it. The strength of our society is based on freedom of information that flows around the world and that's why we have the standard of living, and that's why we have the freedoms that we do. But we're beginning to be worried that the rules and regs which are about to come out—and I understand they're in OMB now for chop—that they will not go far enough in ensuring those freedoms.

Mr. **SCHEUER**. That's very interesting and I applaud you for your interest and concern and leadership. I'd like to ask you, when is the Radio and TV News Directors Association going to set up a task force on contraceptive advertising and the rules and regs that the three networks themselves have applied to block out to the public any information about contraceptive advertising, about the use of condoms as a preventative for two terrible blights our country is facing.

One is AIDS and the other is early teenage, out of wedlock pregnancy. When are you going to address that question of self-censorship, by which the three networks are shooting themselves in the foot every day, losing credibility, and violating the First Amendment in a very real way?

Mr. **BRENDER**. With all due respect, sir, I'm strictly here on remote sensing, unless you want to put one over a satellite. I'm just not in a position to talk about that. [Laughter.]

Mr. **SCHEUER**. I don't think either our reach or the condom's reach would stretch that far. [Laughter.]

You might think, as you sit there, this guy is not real. I have met, and other members of Congress have met with me, with every single one of these standards and practices officials at your network, the guys two or three levels down, behind whom your chief executives and chief operating officials hide. We've met with Al Schneider of your network and tried to elicit from him some kind of explanation of this bizarre policy on the part of all three networks, as to why they are censoring their reach to the American public.

This greatest information gathering and mind-altering technology that humankind has ever developed, they're closing it off for this urgently needed message, that you can protect your health, protect your life, protect your future by controlling your fertility and engaging in responsible sex.

Maybe you feel this isn't the time and place for me to engage in this soliloquy and you're probably right. But I, and other members of Congress, are very frustrated at this policy of self-censorship on the part of the networks.

I totally agree with you about your First Amendment concerns up there in space, and I congratulate you on having your leadership and having the Television and TV News Directors Association address themselves to it. Can I leave you with a message that I think it would be great if you could get your colleagues to address themselves to the question of why you engage in self-censorship on contraceptive advertisement and the use of condoms?

And just so that you won't be too much taken in by Al Schneider and others of his colleagues in the standards and practices spot, in your organizational structure, telling you how offensive this is and how it would shock the American public, I'm going to give you right now—even as we sit here—a copy of a poll that Lou Harris has done, entitled "Attitudes about television sex and contraceptive advertising" finished in the last 30 days, in which he makes it perfectly clear that the overwhelming percentage of the American public favors more sex education on television, favors contraceptive advertising, favors information about how the use of condoms will affect our national health and national sanity.

With apologizes for this, what you might consider, irrelevant exercise, I will thank you very much for extending your leadership to this subject, engaging some of your colleagues in the Radio and TV News Directors Association in the importance of this section.

I apologize to my co-chairman for this little diversion from the purpose of our hearing and I yield back the balance of my time.

Mr. **Hall**. I think it's a very good indication and illustration that the Chairman, when he is the senior member, can—no pun intended—stretch the jurisdiction and bring a little sex into the Landsat area. [Laughter.]

Maybe it will help the House next time.

I think, if I may just ask you, Mr. Brender, you mentioned the Chernobyl story and compare, if you can, the performance of the French and the EOSAT systems and the information that you were able to glean from that, and in turn pass on to the American people?

Mr. **Brender**. Initially, you could tell that the fire was outwardly under control, that that part of the world was not glowing red. And it looked like a pretty normal scene, so I think it had a soothing effect on the world, because otherwise the world had no idea what was going on in that part of the world.

You could at least see that they had the fire outwardly under control and I think that was an important image to present. We were told by people in government that there was two meltdowns and, in actual, there was only one. But it's just like with any breaking news story, there's a lot of information that comes out, some of it wrong initially, just like with the Amtrak accident north of town here, initially some wrong information.

Mr. **Hall**. And it can be soothing, in the place of startling on many occasions?

Mr. **Brender**. It has a—it can reduce conflict, reduce tension and not enhance it.

Mr. **Scheuer**. Mr. Chairman, I've been very impressed with these witnesses and other witnesses. I have to leave now, but I would ask unanimous consent that members be permitted to introduce questions by mail to the witnesses and hold the record open for ten days or two weeks for responses to those questions.

Mr. **Hall**. Be glad to do that, Mr. Chairman.

If you leave, we hope you'll come back because you certainly bring excitement and enthusiasm to the hearing. [Laughter.]

We thank you gentleman. It has been an informative panel.

Now we'll have the next panel for research applications, Mr. Taranik and Jim McCarthy of Harvard.

All right, if you gentleman are ready?

At this time, we'll recognize Dr. Taranik.

STATEMENT OF DR. JAMES V. TARANIK, DEAN, MACKAY SCHOOL OF MINES, RENO, NV; AND JAMES J. McCARTHY, HARVARD UNIVERSITY, CAMBRIDGE, MA

Mr. **Taranik**. Thank you, Mr. Chairman.

Mr. **Hall**. You have been here as we requested that you limit your initial presentation?

Mr. **Taranik**. Yes, I have.

Thank you for the opportunity to participate on this panel as Chairman of the Remote Sensing Subcommittee of NASA's Space Applications Advisory Committee.

As you know, our advisory committee has been looking at the issue of Landsat very carefully. We feel that the Landsat program is an essential national asset. It is essential to the understanding of changes in earth systems that may be occurring on a global basis and that may ultimately affect the future utilization of our planet.

It is a key technology utilized by our resource industries to compete effectively in the world marketplace. It is an important technology for our state and federal agencies that is used to manage our nation's resources and environment. Landsat has stimulated the growth and development of new aerospace remote sensing industries for our national economy. It has been a significant factor in improving our foreign relations with countries that have resources needed by our national industries and we feel that the program is competitively positioned to continue to stimulate the growth and development of our national economy, provided that the program is given the opportunity to succeed.

Commercialization of the Landsat program has been a problem in the United States because of a lack of a national agenda for stimulating the development of new industrial opportunities for our national economy. The more competitive foreign governments have organizations that directly influence new commercial ventures and the development of new technologies that will maintain and stimulate the continued growth of their national economies.

As I was preparing this testimony, I happened to come across the most current issue of Business Week, relating to super conductors.

In an article relating to these astonishing breakthroughs in super conductivity research, there is an editorial entitled "The U.S. has the advances, but Japan may have the advantage." The article states that Japan's Ministry of International Trade and Industry, MITI, has begun assembling a consortium of government, industry, and university researchers to do work on the new commercial applications for the new super conductors developed in the United States.

It's not surprising that MITI has been spearheading Japan's entry into the earth observation satellite business and personally, when I was in Japan in 1981, I got a briefing with two other professors by the director general of MITI, by a consortium of Japanese businessmen concerned with the advancement of their economy, and by some of the professors from the Tokyo University where they explained to us exactly why they were going to acquire and develop earth resources observations data on JERS-1 and why it was a major national priority.

Our group has been looking about what should be done, and I'll give you my personal opinions. We definitely believe that the government should fund a two-satellite program now, including the launch costs and operations costs for Landsats 4 and 5. We feel that the government should support——

Mr. HALL. Could you hold that just a moment?

Go ahead. Thank you, Doctor.

Mr. TARANIK. The government should support basic and fundamental research within NASA and that's what this panel is dealing with today, to improve sensor design, improve understanding of what can be measured with new, proposed Landsat sensors like the five band thermal IR sensor and the panchromatic sensor that have been mentioned before. And also to develop new applications of Landsat data.

All of this, we feel, is more or less mandated and required by the Landsat Commercialization Act of 1984. I'll be glad to speak to any of those technologies if the time permits.

We feel that the government should establish and adequately support national centers of excellence in land remote sensing that will assist in the development of new applications for Landsat data and other remote sensing data sources that will stimulate expansion of the user community.

Finally, we feel that the government should establish a national oversight group to advise the executive branch in the Congress equally on several remote sensing programs and that has been a recommendation that has come out of a variety of advisory committees that I've been a part of over the last six years.

Mr. Chairman, this nation needs to invest in its economic future by ensuring that the Landsat program is adequately managed and logically developed for the benefit of all Americans.

Thank you.

[The prepared statement of Mr. Taranik follows:]

Statement of

Dr. James V. Taranik
Dean, Mackay School of Mines
University of Nevada-Reno
and
Chairman, Remote Sensing Subcommittee
NASA Space Applications Advisory Committee

Before the

Subcommittee on Natural Resources,
Agricultural Research, and Environment

Subcommittee on International Scientific Cooperation
of the
House Committee on Science, Space, and Technology

April 2, 1987

Mr. Chairman, I am Dr. James V. Taranik, Dean of the Mackay School of Mines at the University of Nevada-Reno. Thank you for the opportunity to testify regarding the Landsat program. I have been involved with this program professionally for over 15 years as a Chief of Remote Sensing for the Iowa Geological Survey, as a Principal Applications Scientist at the U. S. Geological Survey's EROS Data Center, as a Branch Chief at NASA Headquarters, and as a NASA Principal Investigator in various Landsat programs. I chaired the Working Group on Commercialization that studied commercialization of the land and weather satellietes for the Secretary of Commerce, and recently I assumed chairmanship of the NASA advisory Subcommittee that deals with Remote Sensing of the Earth's atmosphere, hydrosphere, biosphere, and lithosphere. This Remote Sensing Subcommittee is a part of the Space Applications Advisory Committee of the NASA Advisory Council. The Remote Sensing Subcommittee has recently reviewed the current situation related to commercialization of the Landsat program and in February 1987 made recommendations to the Associate Administrator for Space Science and Applications. I would like to share some of my observations regarding the Landsat program.

NATIONAL IMPORTANCE OF LANDSAT

The Landsat program has evolved from an experimental program to an operational program that is a national asset to this country. The program not only serves scientific needs, but also has served as a catalyst in stimulating the devlopment of new industrial opportunities for our country and is an important instrument of our foreign affairs.

1. Continuous acquisition of Landsat data since 1972 has provided a baseline of Earth observations data, which allows long-term changes to be assessed in the Earth's land areas. The key element of this baseline of data is nearly continuous, repetitive, global multispectral observations of the Earth's land areas. No other country has or plans to acquire such a data set. This data set is essential for NASA's Global Earth System Science program and other Earth observations programs of national importance.
2. Landsat sensors have evolved from a 4-channel Multispectral Scanner to a 7-channel Thematic Mapper. No other satellite system has the combination of spectral and spatial resolution as the Landsat TM.
3. The next logical step in the evolution of the Landsat system is the inclusion of a 15-meter Panchromatic Band and 5 channels in the thermal infrared. These planned new capabilities will greatly increase the utility of Landsat data in the next decade. No other country will be able to provide this enhanced measurement capability. These new measurement capabilities will greatly expand the utility of Landsat data and its desirability in the international marketplace.
4. Recent developments in computer technology now allow the most sophisticated Landsat data analysis techniques to be accomplished on desk-top personal computers. Therefore, the user community will expand rapidly in the near future, and low-cost portable computer systems will be routinely utilized throughtout the world for analysis of Earth observations satellite data.
5. The development of the Landsat program has caused the creation of new opportunities for the industrial sector of our national economy. Our resource companies now routinely use Landsat data in mineral and energy exploration and development because such data improves the effectiveness of such exploration and development in poorly mapped areas of the world. New companies have developed, which provide hardware and data analysis services to users of Landsat data on a worldwide basis.

6. The Landsat program has been a significant factor in improving foreign relations with lesser developed countries and in aiding them in developing and managing their natural resources. Many of these countries have strategic mineral and energy resources that are important to our national economy. A number of countries have developed resource management programs based on Landsat data, and some have developed Landsat data reception facilities in anticipation of continued availability of Landsat data.

Therefore, our national Landsat program is competitively positioned to create new industrial opportunities for our national economy in the international marketplace. At the same time, the Landsat program is essential for the scientific study of changes in global Earth systems that may be important for the continued utilization of this planet by mankind. Finally, the Landsat program is an essential element of our foreign affairs with lesser developed countries.

COMMERCIALIZATION OF THE U.S. LANDSAT PROGRAM

In the mid 1970s the Office of Management and Budget (OMB) evaluated governmental programs to determine if they could be more efficiently managed by the private sector. Guidelines were developed (A-76) that produced the mechanism for "privitization" of governmental programs, and Landsat was identified as a program that might be better managed outside the Government. In the late 1970s the Administration recommended that Landsat should be "commercialized" and the Administration recognized that successful commercialization of an experimental government program would require government support for the successful transition of the program to an operational commercial program. In the late 1970s the Government recommended that successful commercialization would require support for at least four satellites yet to be flown: Landsat-D (now 4), Landsat-D' (now 5), Landsat-D", and Landsat-D"". Under this commercialization program, transition of the Landsat program to an all-industry program would be completed by the end of the 1990s.

In 1980 OMB recommended expediting transfer of the commercialization of Landsat to the private sector with a two-satellite program, thereby saving the government approximately $500 million. In 1981 the Administration instructed the Department of Commerce to consider two alternatives for the Landsat program:

1. Cancel the Landsat program
2. Commercialize the program with a two-satellite program to the private sector.

In 1982 the Secretary of Commerce appointed a Civil Operational Remote Sensing Satellite Advisory Committee (CORSSAC) to evaluate options related to commercializing the Landsat program, but that committee also was asked to evaluate commercializing the weather (meteorological) satellites as well. The minutes of the CORSSAC meetings attest to the fact that most of the committee members did not agree that only the two alternatives above be considered. The CORSSAC committee strongly recommended that a third alternative be added to the list because of the national importance of the Landsat program:

3. Allow the program to remain in the Government, if commercialization does not appear to be feasible.

It is important to note that the weather satellites were added at a later stage to the Landsat commercialization considerations. They were added for study by the Administration because OMB realized that the Landsat market was undeveloped, that a two-satellite land observing program would not generate enough revenue to result in successful commercialization, and that the volume of weather satellite data needed by the Government could carry the Landsat program successfully to commercialization. Also, the OMB had an unsolicited proposal from the Communications Satellite Corporation that involved management of both the land and weather satellites. Commercialization of the weather satellites was withdrawn from consideration when Congress discovered that the Under Secretary of Commerce had been negotiating for a management position with COMSAT. Subsequently, COMSAT withdrew from consideration in the Landsat commercialization program.

In 1983 and 1984 the Working Group on Commercialization of CORSSAC reviewed 14 informal proposals to commercialize the Landsat program. This review identified four groups of serious proposers. The Working Group on Commercialization also reviewed the Department of Commerce formal Draft Request for Proposals. Finally, the Department of Commerce selected two groups of proposers for contract negotiations, EOSAT (Hughes, RCA, CSC, Earthsat) and KODAK (Fairchild, ERIM, TRW). Both proposers were informed that approximately $500 million would be available to operate the Government's experimental program and for the transition of this program, using two satellites, to an operational commercial program. When the 1984 Landsat Commercialization Act was passed, OMB reduced the amount available to the Landsat commercialization contract to $250, with Landsat-4 and -5 operations and launch costs extra. KODAK withdrew from consideration under protest, and that left only EOSAT under consideration.

Beginning with the FY 1986 Budget released in January 1985, OMB has not recommended funding for the Landsat program to the Congress. In negotiation with the Government during the period 1984 through 1985 EOSAT was asked not to utilize expendable launch vehicles (ELV's) and was asked to come up with a plan to integrate Landsat into a Shuttle payload. After signing its contract in September 28, 1985, EOSAT was asked to develop a multipurpose spacecraft bus (OMNISTAR) for Shuttle launch, and that would carry other Earth-serving instruments. When the Challenger disaster (STS 51-L) occurred on January 28, 1986 large changes in the Shuttle program occurred, and EOSAT was first asked to launch Landsat-6 on an ELV and Landsat-7 on the Shuttle. About mid-1986 EOSAT was asked to drop the Shuttle launch plan completely, but keep the OMNISTAR launch concept and launch on a Titan IV Centaur. Finally, EOSAT was asked to come up with a two-satellite launch plan, but without OMNISTAR. These program changes were very costly, amounting to over $25 million.

While all these program changes were occurring in FY 1986 and FY 1987 the OMB did not recommend funding the Landsat commercialization effort out of new appropriations. Instead, the Department of Commerce was asked to submit budgets that would reflect reprogramming of funds to acheive Landsat commercialization. Accordingly, in late 1986 the Department submitted a $209 million budget for one satellite, $50 million for ELV launch costs, and $25 to $30 million for continued Landsat 4 and 5 operations. The House evaluated this request and commented that a one-satellite program would not lead to successful commercialization and the request was reluctantly passed to the

Senate for their consideration. The Senate rejected the Department of Commerce proposal because it was doubtful that a one-satellite program would lead to successful commercialization. The Under Secretary of Commerce sent a letter to OMB in March 1987 outlining a $295 million, two-satellite program, $70 million in launch costs (two satellites), and approximately $25 to $30 million for Landsat-4 and -5 operations. The letter requested guidance on how to proceed and indicated that either the two-satellite program should be approved or that the commercialization effort should be cancelled.

FOREIGN CIVIL OPERATIONAL SATELLITE PROGRAMS

France and Japan have recently developed civil Earth observing programs, which have a commercial dimension but are heavily supported by their governments. The French SPOT program is managed by SPOT Image. That French corporation is 40% owned by the French national space agency, CNES. The French government wants SPOT to "pay for itself" to the degree possible as a commercial venture. However, it also realizes that French governmental agencies need the data, the data can be used for improving relations with foreign governments that provide the French economy with needed raw materials, and that new French industries will be created for processing and interpreting SPOT data and such instrumentation will be purchased throughout the world.

The Japanese, on the other hand, do not care whether their MOS-1 and JERS-1 satellites pay for themselves through the sale of their data. The Japanese civil operational satellites are viewed as critically important Earth resources intelligence collectors that will be used by the Japanese Geological Survey, Metals Institute, and Japanese Petrolium agencies for identifying key areas for exploration and development of nonrenewable natural resourcs needed to sustain the Japanese industrial economy. In addition, the Japanese recognize that new high-technology industries could also be created for processing and analyzing Earth observations data and that there is an expanding world marketplace for such instrumentation. In fact, the Japanese are not firmly committed to the principle of "Open Skies," and they may not make their data available on a universal basis. Therefore, the Japanese program does not appear to be a commercial remote sensing program, but is a civil operational program.

It is important to recognize that both France and Japan lack an intelligence reconnaissance satellite program, and that both countries plan to utilize their civil operational satellite programs to fulfill the needs of their intelligence agencies. It is also important to note that both France and Japan have a partnership relationship between industry and government and that this relationship is designed to create new industrial opportunities in the world marketplace for their national economies. The French and the Japanese fully realize that new industrial opportunities will lead to new products and that people will have to be employed to manufacture these new products. They realize that the employment demands of their countries can be met through the creation of new industries that are competitive in world markets.

WHY IS COMMERCIALIZATION OF THE LANDSAT PROGRAM A PROBLEM IN THE UNITED STATES?

The reasons are numerous; however, the significant problem is the lack of a national agenda for stimulating the development of new industrial opportunities for our national economy. Only within the last few months has the subject of "competitiveness" of our national economy in the world marketplace become an issue of national concern. The more competitive foreign governments have organizations that directly influence new commercial ventures and the development of new technologies that will maintain and stimulate the continued growth of their national economies. In the April 6, 1987 issue of Business Week, in an article related to the astonishing breakthroughs in superconductivity research in the United States there is an editorial entitled, "The U.S. Has the Advances, but Japan May Have the Advantage." The article states that Japan's Ministry of International Trade and Industry (MITI) immediately began assembling a consortium of government, industry, and university researchers to work on new commercial applications for the new superconductors developed in the United States. A MITI official describes the ministry's goal: "to exploit the fantastic world of future industries with missionary zeal." It is not surprising that MITI is spearheading Japan's entry into the Earth observations satellite business.

If the United States were similarly organized to improve its competitive posture in the world marketplace, we would not consider letting the Landsat program fail. The major consideration would be to ensure that the program is properly managed to support continued development of our national industrial base.

WHAT SHOULD BE DONE?

The United States Government should adopt a philosophy that the civil operational Earth observing programs are national assets essential to the orderly growth and development of our national economy. Our national approach should be to seek ways of managing these national assets that are in the best interests of the public at large. The Landsat program has been a continually evolving program where experimental sensors become operational sensors as the utility of their data becomes better understood. Therefore, the following steps should be taken to ensure that our national industries will be able to take full advantage of the data Landsat provides in the future:

1. The Government should fund a two-satellite program now, including launch costs for two satellites and operating funds for the existing Landsat-4 and Landsat-5 satellites. This program is understood to be $295 million for development and flight of Landsat-6 and Landsat-7, $70 million in launch costs for two satellites, and $25 to $30 million for Landsat-4 and Landsat-5 operation. This funding should not come at the expense of other NOAA programs but should be a new appropriation.

2. The Government should support basic and fundamental research within NASA to improve sensor design, improve understanding of what can be measured with new Earth observations instruments, and to facilitate the development of new applications of Earth observing satellite data.

    (a) The Government should support development of a 5-band thermal infrared focal plane for flight on Landsat-6. The estimated R&D costs for this development are $10 million.

    (b) The Government should fund research with multiband thermal infrared data acquired by aircraft, and it should fund laboratory research to thoroughly understand the types of natural resource information that can be extracted from the multiband thermal infrared data, which will be acquired by Landsat-6. This research is essential to the systematic development of new markets for Landsat data.

    (c) The Government should adequately fund advanced sensor research to include development of a thermal infrared spectrometer for flight on spaceborne platforms. This spectrometer will allow full understanding of the potential for the development of new instruments that will improve the utility of Landsat data in the thermal infrared portions of the spectrum.

    (d) The Government should fund the development of focal plane technology leading to the development of multispectral linear and area array imaging instruments that can be utilized on later generation Landsat satellites.

    (e) The Government should adequately fund the investigation of imaging spectrometer data to be acquired by NASA as part of the Airborne Imaging Spectrometer program.

3. The Government should establish and adequately support national centers of excellence in land remote sensing as recommended by the National Commission on Space. These centers could act as focal points for assisting users of Earth observations data in understanding the types of information that can be extracted from such data and how this information can be used to manage natural resources more effectively.

4. The Government should establish a national oversight group for our national civil operational Earth observations program. This group should be able to advise the Executive Branch independently of the federal departmental and agency structure and its findings also should be equally available to the Congress.

   (a) The oversight group could identify barriers to successful commercial remote sensing programs and recommend solutions for removing those barriers.

   (b) The oversight group could identify needs for basic research and applications research that would improve the ability of our national economy to compete in the world marketplace. These recommendations have been made in different forms by a variety of advisory committees related to the Landsat program. The research programs outlined above are within the spirit and intent of the Landsat Commercialization act of 1984.

SUMMARY AND CONCLUSIONS

The Landsat program is a national asset that is essential to the development of new industrial opportunities for our national economy in the international marketplace. The Landsat program provides Earth observations data that are vital to understanding the long-term changes in global Earth systems that may ultimately affect the use of planet Earth by mankind. The Landsat program has been an important technology in the development of foreign relations with lesser developed nations that have resources important to our national economy. This nation needs to invest in its economic and political future by ensuring that the Landsat program is adequately managed and developed for the future. Mr. Chairman, thank you for this opportunity to appear before your committee.

Mr. Hall. Thank you, Doctor. I recognize Dr. McCarthy.

Mr. McCarthy. Thank you, Mr. Chairman.

Mr. Hall. Let me once again reiterate that don't judge the lack of attendance by the other members of the committee by their failure to be here today, because we have many committees operating at this time and a very critical in the budget process, and we have them running back and forth here. If Mr. Scheuer is gone, I hope he's gone for help. Maybe he'll bring some others back.

Go ahead, Dr. McCarthy. Your full statements will be in the record and will be read and will be appreciated and will be used, so you're not just talking to me. If you were, we might all three go to Bullfeathers and really get it on. Go ahead, Dr. McCarthy.

Mr. McCarthy. Thank you. I'm James McCarthy, a biological oceanographer from Harvard University. In your letter, I was asked to address the importance of Landsat to global environmental monitoring, including global exchange program.

Remote sensing of terrestrial and ocean properties with projection equipment that will be flying on Landsat 6 and 7 figure prominently in national and international plans for large scale science endeavor that falls generally under the rubric of Global Change in the International Geosphere Biosphere Program.

Since its birth, more than 4 billion years ago, this planet has been changing for sure. The record of the past, the fossil record, the record of isotopes in deep sea sediments, the distribution of pollen for different species of plants in lake sediments, and the small samples of the atmosphere of the past that are trapped in gas bubbles in the glacial ice in the polar regions, have shown us that change in the last million years has been profound, but also relatively slow.

We've had glacial to interglacial cycles of about 100,000 frequency. Importantly, the chronology of these changes have demonstrated unequivocally that there are powerful linkages between this physical climate system—that is, the temperature of the planet, its climate as manifested locally in weather, and biogeochemical cycles.

When the earth is warmer, we know now that the carbon dioxide of the atmosphere is higher. When it's cooler, we know the carbon dioxide content of the atmosphere is lower. This is again, known from the record of the past. These are due to natural fluctuations in this very important greenhouse gas, carbon dioxide.

A key linkage between this part of the physical system and biogeochemical cycles is now known to involve both land and ocean organisms. Although human kind are far more dependent upon terrestrial vegetation than on marine vegetation for our food, our fiber, our energy, the ocean system—particularly its organisms—are key actors in this global system that regulates the climate of planet earth.

The fact is that most of the carbon dioxide that has been outgassed from our planet over the course of its life, in the last 4 billion years, is now on the bottom of the ocean in the form of marine sediments. This is, of course, distinctly different from the atmosphere that makes our earth distinctly different from our sister planets Venus and Mars in that those atmospheres still contain a great deal of carbon dioxide.

With this understanding in hand, scientists across the earth sciences, broadly that is geologists, meteorologists, oceanographers, and ecologists, have called attention to our need to understand these linkages between the climate systems and these geochemical cycles.

Quantitatively, accordingly, we must be quantitative in order to predict with confidence the changes that might occur in the next decade or centuries in the earth's biosphere and the feedback from these changes to climate. This is not just a lofty goal.

Among this community of scientists, there's a sense of urgency to develop this qualitative understanding. The reason, of course, is that our industrialized society is greatly perturbing this delicate balance in the earth's environmental system, through a liberation at ever increasing rates, of greenhouse gases such as carbon dioxide, freon and methane.

Nationally, this challenge has been recognized by our funding agencies in the earth sciences. In NASA this is referred to or is a major part of what is referred to as Earth System Science. In NSF, these studies are a major part of what is being termed Global Geosciences. Complimentary roles are being developed for the other agencies. Internationally this new program—it's been given the term the International Geosphere Biosphere Program, and it has just been initiated.

So from Landsat we have data for the last 15 or so years, which gives us a global distribution for terrestrial vegetation, watersheds, places where we can first expect to see a change that we now predict for climate. Extent of forests, of deserts, and even the physiological state of many of the terrestrial plant communities can be assessed with Landsat imagery. The wise management of earth resources for the future, uses of food, fiber and energy, will depend upon knowing where these now predicted effects of climate will be most severe.

For the ocean, the effect is more subtle. Again, with respect to these basic needs of human populations for certain but perhaps even more profound in a different sense. That is, climate change will almost certainly alter the patterns of productivity in the ocean which will change the capacity of the ocean to extract carbon dioxide—again an important greenhouse gas—from the atmosphere.

Only within the last decade has the earth science community become aware of the power of this remote sensing capability for the study of the life support system of our planet. Groups of dedicated scientists, both in the agencies and the academic community, have developed the capability to use this remotely sensed information to understand the distribution of these properties and the interactions between them.

In fact, only within the last few months has the first global image for the ocean plankton distribution generated with data from the now-defunct Coastal Zone Color Scanner been developed. I have a copy of that here. It's a dramatic image. It would certainly take much longer than I have in this testimony to give you an adequate figure legend, but one sees here, in the dark shades of gray, are the continents. You see, between the continents, the blue areas which are areas of low plankton concentration. The bright areas are areas of high plankton concentration.

This is generated by Dr. Esaias and Feldman at the Goddard Space Flight and again demonstrates for the first time the global synoptic capability for observing this ocean property, one that is key in these global biogeochemical cycles.

Landsat 6 will provide essential continuity in the land observations and it will permit the resumption of the ocean sensing capability that is demonstrated in this image, both of which are essential for understanding of the processes that regulate climate and the response of the biosphere to changes in global climate, which are now being predicted for the next few to several decades, into the next century.

Thank you.

[The prepared statement of Mr. McCarthy follows:]

Testimony

by

James J. McCarthy

Alexander Agassiz Professor of
Biological Oceanography
and
Director of
Museum of Comparative Zoology

Harvard University

before

The United States House of Representatives

Subcommittees on

Natural Resources, Agriculture Research and Environment
and
International Scientific Cooperation

2 April 1987

THE RELEVANCE OF LANDSAT IN THE STUDY OF GLOBAL CHANGE

The history of planet Earth, since its formation more than four billion years ago, is a story of change. The continental masses slowly acrete and reposition as new ocean floor is formed at the mid-ocean spreading centers. Uplifting of continental crust forms mountains, which are constantly being worn down by weathering processes. The solar energy our planet receives varies both as our solar system's star ages and as a function of periodic oscillations in earth-sun distance.

The evolution of modern life forms over the last three and a half billion years denotes both a change and a cause of change in our planet's environment. The earliest forms of life contributed to the evolution of the basic life support system itself. The chemical composition of the atmosphere is a case in point. It has evolved to its present state, one with about 20% oxygen and only a trace of carbon dioxide, partly as a result of life processes. Plants necessarily preceded animals in Earth's evolutionary scenario, and a waste product of their photosynthetic activity, free oxygen, is released to the atmosphere. One molelcule of oxygen is released for every molecule of carbon dioxide that is incorporated into the tissues of plants. The respiration process of animals, bacteria, and even plants reverse this process as oxygen is consumed and carbon dioxide released in the course of an organisms' metabolic processes.

The excess of oxygen relative to carbon dioxide in our contemporary atmosphere is a consequence a bottleneck in this cycle. The dominant global sink for carbon is the vast reservoir of marine plankton remains, which is stored in the sediment layers of the oceans. With time both biological and chemical processes recycle some of this bound carbon back to carbon dioxide, which is dissolved in seawater. This gas is ultimately released, when in the course of ocean circulation, the deep waters return to the ocean surface where the excess carbon dioxide escapes to the atmosphere. However, most of the carbon contained in the deep sediment reservoir is released through an even slower process, the uplifting of this ocean sediment material at the oceans' margins. When exposed to the atmosphere, chemical weathering processes consume oxygen and release carbon dioxide from the ancient sediments.

Within the last decade we have learned from the isotopic content of these deep-sea sediments and from the chemical composition of bubbles of ancient atmosphere trapped in polar ice that the balance between atmospheric carbon dioxide and oxygen undergoes changes during glacial to interglacial transitions. These ice age cycles have occurred about every 100,000 years over the last million years.

With increasingly rapid development of our industrialized society in the last century and a quarter, we have accelerated the rate at which carbon is being returned from one compartment of the sediment reservoir to the atmosphere. With the extraction of fossil fuel from sediments of ancient inland and marginal seas and its combustion to carbon dioxide, the enhanced rate of return is now resulting in higher concentrations of carbon dioxide in the atmosphere than have occured at any time in the last few hundred thousand years.

An additional factor, the magnitude of which remains difficult to estimate, is role that terrestrial biota, particularly forests, as reservoirs for carbon. In the last several hundred years it has been common practice to clear forests from lands as new territories are settled. In much of northern Europe and North America these forests can be reestablished in the course of several decades. In tropical regions, however, it is clear that this process is much less likely to be reversed on such time scales. To the degree that the biomass in tropical forests is currently being diminished without compensatory increases in biomass elsewhere, the process of deforestation represents a net flux of carbon to the atmosphere.

Earth is the warm hospitable place it is as a result of the "greenhouse" gas effect. Certain naturally occurring gases like water vapor, carbon dioxide, and ozone provide an insulating blanket, without which the surface temperature of the planet would, on average, be near the freezing point of water.

What is clear from the last few decades of research is that this finely tuned system is being perturbed. The anthropogenically mediated flux of carbon from the sediments to the atmosphere is increasing the concentration of an important greenhouse gas in our atmosphere. Atmospheric modelers report that the effect of this increase in atmospehric carbon dioxide together with the combined effect of other greenhouse gases under human influence, such as methane and the freons, is leading our planet into a period which will be warmer than any which has occurred in the last several hundred thousand years.

The consequences of perturbation to the climate system of our planet cannot, at this time, be predicted with much confidence. There are too many unknowns in the nature and regulation of key couplings between the physical climate system and biogeochemical cycles to predict the details, such as regional effects and timing, of the response.

Within the last five years leaders of the earth sciences community in the United States have taken the initiative to encourage a new comprehensive research effort addressing these and related processes, as a program to study Global Change. This initiative has been carried to the international scientific community, and recently it was recognized as a major new program, the International Geosphere-Biosphere Program (IGBP), by the International Council of Scientific Unions.

Within the United States key components of this program are being developed and implemented under the banners of Global Geosciences within the National Science Foundation, and Earth System Science within the National Aeronautics and Space Administration. Complementary commitments to this coordinated program are now being formulated by other agencies, and several other nations are following our lead.

An absolutely essential requirement of this program is a global observing system, a significant component of which is a suite of proven and next generation satellite sensors. The foundation for a predictive capability of global change must be built upon a reliable base of observations, and the refinement of these predictions with time requires continuing documentation of the changes that are occurring. Most of the satellite sensors with application potential for these research issues have only become available in that last decade, and yet with data sets spanning a few years, or only months in some cases, these products have revolutionized our concepts of the planetary dynamic.

LANDSAT imagery, initially with the Multi-Spectral Scanner, and more recently with the Thematic Mapper, now permit detailed characterization of regions where our studies must be focused if we are to document and understand the underlying processes responsible for global change. These data have proven to be extremely valuable to the scientific community. The continuity in this observational capability is essential for the detailed documentation of changes for the areal extent, the community composition, and to some degree even the physiological state of terrestrial vegetation.

A related capability for remotely sensing the distribution of plankton in the ocean is also a possibility for the next LANDSAT satellite. This candidate sensor, known as SEA-WiFS, is a wide-field instrument that uses technology similar to that proven to be of immense value for ocean studies with the now defunct Costal Zone Color Scanner (CZCS) launched in 1978 on NIMBUS-7. With this capability ocean scientists can, for the first time, study the processes responsible for marine plankton photosynthesis and the flux of carbon into the deep-sea on time and space scales appropriate to an understanding of the influence of climate on these ocean processes and vice versa.

Today we are witnessing an unprecedented level of cooperation among scientists in the disciplines of the earth sciences, among the federal funding agencies and the private sector in our country, and among the nations of the world in formulating plans and implementing a study to understand global change in the decade to century time-frame. Scientists have watched with great interest the birth and maturation of EOSAT. Today many share a sense of confidence that this transfer of technology from the Federal Government to the private sector can be effective in facilitating research essential to the Global Change program. A disruption in the LANDSAT program and the loss of opportunity for deploying an ocean color sensor on the next LANDSAT satellite would be an immense setback in the national and international science efforts so urgently needed to chart the future for planet Earth's life support system.

Mr. HALL. Thank you, Dr. McCarthy.

Let me say something that I think ought to be said and ought to be said time and time again, its men and women such as yourselves who have obviously put so much of your life in years and time into research and into fine tuning things that none of the rest of us ever get the opportunity to know about unless you advise us.

I admire you for the disciplines that you've obviously adhered to, as an American. I also appreciate it, as a member of Congress, your willingness to impart it to us.

I just don't think that message gets through enough, as to the fact that you men and women who come from different parts of the country to give us your time and to give us your information. You seem so willing, in the scientific community, to try to offer a bridge to us, to give us the benefit of people who really and truly know what the hell they're doing. We need that.

I want to ask you, Dr. McCarthy, and assure you that your presentations have been studied and read by most of the members already. You stated, on I think page four or five, that international scientific community strongly supported the global change program. We're very interested in that because, as you know, this Congress has just initiated a subcommittee called International Scientific Cooperation. The gentleman to my left is the staff director of that and I think we'd be very interested, and our committee would be, in which international scientific bodies have been involved? Give us some help there in a key or—if you would?

Mr. MCCARTHY. The international scientific body that has been most involved and most effective is the body known as the International Council of Scientific Unions. This is the body that has membership reaching across the globe to involve scientists in all the disciplines of science, in coordinating our efforts and helping to minimize redundancy, to enhance complimentarity, to use the resources of the different nations as wisely as possible in addressing large global scale science issues.

For example, the IGY, the International Geophysical Year 1950s, was a concept that was born in and developed through the International Council of Scientific Unions.

Mr. HALL. I don't suppose there's any question that they're willing to cooperate with respect to planning, but do you feel that we might also get some budgetary commitments out of them?

Mr. MCCARTHY. The International Council of Scientific Unions is not a body that disperses funds to support science. It's a body that helps to coordinate the various national efforts and certainly, to the degree that the task that I have tried to outline ever so briefly in my document, is a task far too large for the scientific community of this country or any other country alone. It will take the participation of many nations, many of the nations of the world and not just those with space capability, not just those with high tech capability, but nations who have scientific communities who can participate in many of the essential ground base observations that are distinctly low tech.

So to the degree that the U.S. scientific effort will be enhanced, in this sort of venture, by the complimentarity of other efforts, certainly there is a contribution from other nations to what I think many of us feel to have been, within the U.S. community in the last few years, one of the most important scientific objectives that we can identify for the near term.

Mr. HALL. I think, in reading your presentation, that other members will surely have questions and would ask your indulgence that we might submit those to you and have your answers submitted for the record, and we'll have plenty of time to do that.

Mr. HALL. Dr. Taranik, I keep talking about the cash register, I guess, but that's pretty important up here. On page 10 and 11, you recommend that the government—really NASA—should fund a number of advanced technology programs in remote sensing and I guess my question is why should the government fund all of these and shouldn't EOSAT be allowed to participate a little bit at the funding level?

Mr. TARANIK. Well, the technology really relates to the status of market development and there's two examples. One is in the thermal infrared, where there are probably only a handful of people around the country that understand multi-spectral thermal infrared data and the kind of information that can be extracted from it and used to do something.

The other example is ocean color where potentially there is a fairly large community that could use ocean color for everything from scientific research to actually, perhaps, targeting fishing operations. In the case of the ocean color sensing, the market may be very close and just providing the measurement capability would result in almost immediate use of the data, whereas looking at global thermal—multi-spectral thermal infrared, we recognize that we need that measurement capability but a fair amount of research is going to have to be done over the next several years so that we understand the types of information that that measurement will provide.

So what we see, in terms of EOSAT's involvement in sensor development in partnership with NASA—and I participated in the working groups that looked at the thermal infrared—is that EOSAT sponsored workshops to define the characteristics, the measurement characteristics. At the same time, EOSAT has sponsored some workshops to look at ocean color.

It looks like the partnership that would evolve is that some—initially we need to do some research with the thermal infrared multi-spectral instrument that EOSAT might, in fact, be able to incorporate on Landsat-6. That would be a tremendous breakthrough for scientific research, both in remote sensing research but also in geoscience research. But that would, in our judgment and the feeling of our panel, was something that where NASA ought to take a leadership role.

With respect to ocean color, it looks like the market is closer there. The phenomenological understanding is better and it looks like perhaps the commercial sector ought to take a leadership role. I think that explains the partnership that we see evolving in this regard.

Mr. HALL. There are a lot of other questions, I'm sure, that would be asked, that might even concern the specific impacts of termination of Landsat, what effect that would have on global environmental monitoring programs, how it affects the precious metal industry and all that, that you can answer, and we will be submitting those to you.

We deeply appreciate your presentations here.

Thank you very much.

Mr. **Hall.** We will hear now from the value added industry, Robert Porter and Charles Sheffield, EARTHSAT Corporation.

STATEMENT OF CHARLES SHEFFIELD, EARTHSAT CORP., CHEVY CHASE, MD

Mr. **Sheffield.** Thank you, Mr. Chairman.

Mr. **Hall.** I understand Robert Porter is not here.

Mr. **Sheffield.** I was just about to say that, but I hope he is not infectious, as I was with him last night.

It's a pleasure to be here today. I'd like to talk a little bit about what we always think of as the rest of the iceberg at Earth Satellite Corporation. I'm talking about the value added industry which often gets overlooked in the discussion of spaceborne hardware and software.

Perhaps I should begin by defining the value added industry, even though people have already referred to it this morning. The data that come back from Landsat or SPOT or Japanese satellites can make spectacular pictures, what David Julyan said is pretty pictures.

But these themselves are not particularly useful. The data become useful when you are able to interpret the image or the data base for information content, when you combine those data with other data that come from geographic or geological or ground survey or tax information bases. It's the process of interpretation and addition and combining of data that we term a value added service.

When you finish doing that, when you've finished performing the value added service operation, the result isn't a picture. Almost always it's some sort of decision and it may be a decision to permit land rezoning or to purchase oil or mineral leases, to buy or sell certain commercial crops, even decisions—and this has already happened—to sign bilateral development agreements between countries.

It's very hard to measure the value of decisions like that. It's even harder to measure the contribution that remotely sensed data make to that process. Many data sources go in, the analysis is performed, and at the end it's difficult to say what contributed what. What you can measure, and what people usually do measure and what they talk about all the time, is not the value of the data. They talk about the cost.

Data are available here, and most people would estimate that for Landsat data at least ten times as much money goes into the interpretation and use of data as in buying it. I should say that that's very consistent with my experience at EARTHSAT. Quite often we will do a quarter of a million dollars worth of analysis on four or five frames of data which are just a few thousand dollars.

If you say that $20 million a year of the current data sales, of that order of magnitude, it means that at least $200 million a year is going already into data analysis and use. If you have any sort of modest stimulus to this process, such as continuity of data, then the numbers go up. As new users come in and as old users move to put data into operational instead of experimental basis, you're seeing increased value and increased cost, too.

Ten years from now, if we continue the domestic program, I expect we will see analysis and use that are in the billions. Since most users will be operating for profit, they won't be subsidized, if I put a value on those data, which I've said is hard to do, it must be higher yet.

I haven't even begun to try and estimate the value of what I think of as unbudgeted or pure research activities, which we heard about just a few minutes ago, in which the next generation of scientists and students contribute not to present applications, but to future science of the country.

Today the use of this remotely sensed data from space seems to me to be limited by two key variables. First of all, there was a lack of familiarity with the data characteristics. You can't accelerate that too much. You can encourage it through education and through sustained availability of data.

It's the second one, the lack of guarantee of continuity, that's the killer here. That's controlled by national and international policies and today the United Stats, on the surface, is on the brink of losing any semblance of continuity in its national land remote sensing program.

OMB seems to regard this program as an activity that is more suited to other countries. The curious thing is the other countries agree with that.

I have a note that I wasn't going to say, but I'll say it anywhere, which is the role of OMB in deciding technical decisions. If you let OMB run the technical decisions of the country, you may as well let the gargoyles run the cathedral, is my way of feeling about it. You can strike that, if you wish. [Laughter.]

The French SPOT satellite has been providing data for about a year. The Japanese MOS satellite has been up for only a month or so. But they're going to be followed. We know that. Other satellites will come, from France, from Japan, from the European Space Agency. Other countries are getting into the field very quickly. Perhaps it's because they recognize something which we seemed to have missed, which is the subsidiary value to the remote sensing industry.

It's beyond the tangibles of data purchase. It's even beyond the more intangible of data value. The real intangibles are the driving force that space remote sensing will provide for other technologies. The most obvious technologies that benefit are computer development, high speed communications, artificial intelligence and electro-optical sensor development.

I don't want to blind anyone with numbers, but remember a Thermatic Mapper image is two billion bits of data and the spacecraft collects that every 30 seconds or so.

These technologies spread through the whole economy and an assessment of their value is even harder than the assessment of remote sensing itself. We have a long way to go in Landsat value added services. 20 years from now, if the program continues, it will be very hard to find places where the data are not used. They will be like census data, it will be in 1,000 places. But like census data, they'll not normally be the only or the largest contributor to a project. It will be a tool. Like any tool, it can pop up anywhere.

The value added service industry was here before the launch of the first Landsat, and I believe it will survive the demise of the last Landsat, if we come to that. But then we will be looking abroad to a satellite, such as SPOT and MOS, for our data, and there will be a discontinuity of development which I regard as very undesirable.

Worse than that, the action will move abroad. It will go to Europe, it will go to the Far East. The technological stimulus that I'm talking about will be over there, and not here.

I would like to see national leadership in what I consider to be a critical technology; but leadership must have continuity of commitment, and we have not seen that. Any businessman knows the consequences of following a policy of being a market follower instead of a market leader. When you look at national market share of an industry like this, you start with a satellite collection system. You find the country that is developing and launching the sensors and spacecraft, and that's where the tip of the iceberg is. Where you find the tip of the iceberg, you'll find the rest of the iceberg.

We work with the French, we work with the Japanese. We have done for many years, but we don't like the idea that we are developing economic dependence abroad. We're going to—be dependent on foreign good will—and that's what it amounts to for data collection, to set data formats, to set delivery schedules, and even to decide if we get the data at all. In a phrase, we will have lost U.S. control.

I want to close with one thought taken from Dennis Gabor, who is a Nobel Prize winning physicist. He remarks that the future cannot be predicted, but futures can be invented. It's easy enough to predict one future in which there is no domestic land satellite program for this country. That, today, is arguably the most probably future.

I would like to request our government, right here, to invent a future in which a strong domestic program can continue and can flourish.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Porter and Mr. Sheffield follow:]

STATEMENT OF J. ROBERT PORTER, JR., AND CHARLES SHEFFIELD
EARTH SATELLITE CORPORATION (EARTHSAT)
BEFORE THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT
AND
THE SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION

April 2, 1987

Mr. Chairmen, members of the Subcommittee on Natural Resources, Agriculture Research and Environment and the Subcommittee on International Scientific Cooperation. It is a pleasure to be here today and present the views of what we consider to be the rest of the iceberg. We are referring to the value-added industry, which is apt to be overlooked in discussions of this nation's land remote sensing programs.

Perhaps we should begin by defining "value-added services." The data returned by Landsat and other earth sensing satellites can make spectacular pictures, but these in themselves are not useful. They become useful when they are interpreted for their information content, or when they are combined with other data, such as geographic, geological, or tax information. It is this process of interpretation, addition, and combination that is termed a "value-added service."

When these processes have been performed, the resulting products seldom resemble anything like a picture. They will usually be decisions: decisions to permit land rezoning, decisions to purchase oil or mineral leases, decisions to buy or sell certain commercial crops - even decisions to sign bilateral development agreements between countries.

The value of such decisions is extremely difficult to measure, and the value of remotely sensed data in forming such decisions is even harder to estimate. Many data sources will have entered the analysis, and it is not easy to quantify the contribution of each.

What can be measured, and what usually is measured, is not value, but cost. Here data are available, and most estimates place the cost of using Landsat data as at least ten times as much as its initial purchase price. When $20 million a year exists in current data sales, as is the case today, at least $200 million a year goes into data analysis and use. Given even the modest stimulus of data continuity, these numbers will certainly grow, as new users enter the field and old users move remotely sensed data from an experimental to an operational basis. A decade from now with a continuing domestic program, the domestic expenditure on data analysis and use will be in the billions; and since most users will operate for profit, without government subsidies, the value of the data will be higher yet. And these numbers do not begin to capture the "unbudgeted" research time of scientists and students, which contributes not to present applications but to future ones.

Today's uses of space remotely sensed data are limited by two key variables: unfamiliarity with data characteristics, and lack of guarantees of continuity. The first can be provided only by sustained use, and though it can be encouraged it cannot perhaps be much accelerated.

The second variable is controlled by national and international policies. Today, the United States appears to be on the brink of losing any semblance of continuity in its national land remote sensing programs. The Office of Management and Budget seems to regard such a program as an activity more appropriate for other countries. Oddly enough, the other nations seem to agree. The French SPOT satellite has been providing data for a year, and the Japanese MOS satellite was launched last month. They will be followed by successor satellites from France and Japan, and other countries are also entering the field. Perhaps they recognize the subsidiary values of the remote sensing industry, beyond the tangibles of data purchase. These intangibles include the driving force that space remote sensing provides for other key technologies. The most obvious of these are computer development, high speed communications, artificial intelligence, and electro-optical sensor development. Like remotely sensed data themselves, these technologies spread through the whole economy, and an assessment of their value is a subtle and difficult task.

Value-added services for Landsat and its foreign relatives have a long way to go. Twenty years from now, if the program continues, the uses of such data will, like those of census data, be found in a thousand places; and like census data, remote sensing data will not normally be the only or the largest contributor to any given project. It will be a tool like many others, and a ubiquitous one.

The value-added service industry for remotely sensed data existed before the launch of the first Landsat. It will undoubtedly survive the demise of the last Landsat, should this country decide that the program is expendable. The industry will then depend upon satellites such as SPOT and MOS, and although this introduces an undesirable discontinuity in data formats, the change to use these other data will be made. The action will move abroad, to Europe and the Far East, and the technological stimulus will be there, not here.

We hope for national leadership in a critical new technology. But leadership requires continuity of commitment. Any businessman knows the consequences of being a market follower rather than a market leader. The determination of national market share starts with a satellite collection system. When you find the country that develops the sensors and spacecraft, you learn where the tip of the iceberg is to be found. And there you will also find the body of the iceberg.

We do not like the idea of such economic dependence abroad — dependence on foreign good will to collect data, to set data formats, to set delivery schedules, and to develop supporting interpretation systems; in a phrase, loss of U.S. control.

This move abroad is certainly a possible future, although as Dennis Gabor, the Nobel Prize winner, has remarked, "The future cannot be predicted; but futures can be invented." It is easy today to predict a future in which there is no domestic land satellite program in this country. It is arguably the most probable future. But we in value-added services would request our government to invent the future in which a strong domestic program can continue and flourish.

Mr. **Hall**. Dr. Sheffield, thank you very much. Your entire statement will be made part of the record.

Were you here when Dave Julyan testified today?

Mr. **Sheffield**. Yes.

Mr. **Hall**. You heard his testimony about their marketing approach. As a value added company, with your knowledge, you're familiar with the French SPOT system, I take it?

Mr. **Sheffield**. Sure, and we work with SPOT data. We're processing it today, back in our offices, I'm sure.

Mr. **Hall**. And you heard Mr. Julyan say that they were not subsidized by their government or by their space agency, but they were a partner. Would you comment on that? You've been pretty forthright and truthful.

Mr. **Sheffield**. It's flummery, sir, all right. Of course, they're subsidized. Their loans, as he said, they have French government participation but $450 to $500 million worth of satellite development costs have gone into that. There's no way that SPOT Image is hoping to recover that within less than several centuries. That, to my definition, is a subsidy, even though you can call it a loan if you choose.

Mr. **Hall**. It seemed like the theme of everything you've testified to, and that that's in your presentation, is a continuity of commitment. My gosh, we've heard that time and time again and that's obviously the thrust and the recommendations that will come out of these hearings. The same in the oil field, the oil patch, where I have the oil patch in Texas, Kilgore, Longview, Bladewater, Tyler, that area. We can make money with $18 or $20 oil. We have to have some stability, we have to have some continuity. I think that's—I hear you saying that, more than anything else.

We understand that the Soviets might be entering the commercial remote sensing arena. Are you aware of any Soviet initiatives in this?

Mr. **Sheffield**. I can tell you hearsay of what I've heard abroad, and I can also tell you what I saw.

Mr. **Hall**. We like hearsay up here.

Mr. **Sheffield**. I'll also give you what I saw with my own eyes. Let me begin with that, because in a way it's more impressive. Two and a half years ago, I was looking around at the Chinese space program and they showed me the Long March 3 rocket and that was nice and they showed me the centrifuges and the vacuum test facilities, and that was great. But the thing that they showed me, that they seemed proudest of all of us, was in Xian, in the middle of China. They showed me a linear array, which is the same type of device as is used on the French SPOT satellite.

They said, "we're going to be using this in a few years in our own remote sensing satellite." That, to them, was probably the high point of their technology, and they were very careful to point out that they had developed this themselves. They had not bought components as, in fact, the French had, from the United States.

Now let me talk about hearsay. There have been rumors that the Soviet Union will go into commercial marketing of remotely sensed data. But more important than that, I think, is the fact that if you say that they launched their own multi-spectral linear array in

1982, which is—let's see, the French launched last year—so that's four years ahead of time.

You can bet if the technology we know about is 1982 linear ray, there's something much better than that, that we don't know about. Where's the tip of their iceberg? So I would not be surprised to see the Soviet Union come into that activity. I would be surprised to see them succeed. Let me say why I say that.

I believe that the principal problem with the program we've had in this country so far has been it was considered as an experimental program and it was a government program. As long as it was in the government, it did not have the marketing know-how, the business knowledge to make it an industry. It has been trying to be a business for one year or so, but it has to survive the transition period in which people have thought of it as a research government activity and not as a full business enterprise.

You can't survive that transition without some funding, and those are the funds that we were looking for the government to provide. In the Soviet Union, I believe the system will never produce a viable, marketable product for land remote sensing. For instance, delivery schedule is important. I don't believe the Soviet system is, in any way, capable of efficient delivery.

I'm not saying I welcome them entering the arena, I disagree with Mr. Julyan. I'm not sure that competition helps us at all. But I am not afraid of Soviet competition, which is a different statement. What I am scared of is Japanese and French competition.

Mr. HALL. Let's get to that. It's been suggested that the Japanese might not even market their remote sensing, that they might just restrict it to Japanese use for identifying or developing strategic resources. Comment on that and tell us what you know or what you've heard.

Mr. SHEFFIELD. It's not a bad idea, if you think about it. We're in a glut situation and——

Mr. HALL. They might do that.

Mr. SHEFFIELD. I don't have to tell you the situation on oil and gas at the moment, if you're from Texas. We're in an even worse glut, possibly, on minerals. But that's going to change. Ten years from now, we'll probably be wondering where the next barrel comes from.

It's not a bad policy for a country, like Japan, to use remotely sensed data to work out deals with other countries in which the other country gets the benefit of the data and of the interpretation and the Japanese get favorable trade concessions. We've had experience with that with the Japanese, before their spacecraft existed.

I am covered by commercial confidentiality, which means I cannot—in an open forum—talk about that, but I will be happy to tell you privately of at least one significant case in which the Japanese bought data, interpreted it, and used it to write a deal with a third country. That's already happening. It's the logical thing to do.

If you want to have that sort of system, the U.S. has never gone for that sort of system. We have made data available to everyone. That does not mean, as other people have said, Fred Henderson, sitting right here said it, that other countries will follow the U.S. lead. They may decide their own national benefits are optimized by keeping data for themselves, and using it in the international arena for resource analysis and bilateral agreements.

Mr. HALL. Only the price would vary, depending upon our ability to participate?

Mr. SHEFFIELD. What do you mean by our ability to participate?

Mr. HALL. That they would make available to us their findings if we didn't have the ability to find our own findings?

Mr. SHEFFIELD. That's a charitable interpretation. They might not choose to make it available at all.

Mr. HALL. They certainly wouldn't have to, and they'd run a rougher deal on us.

Mr. SHEFFIELD. When somebody discovers an oil field, they usually get a lease on it before they talk about it, right?

Mr. HALL. We've kicked OMB around, we've kicked the Japanese around a little now.

Mr. SHEFFIELD. Who's left to kick?

Mr. HALL. Poor little OMB has a hard job and I think we do put an awful lot of them and expect a lot of them and we're hopeful that these hearings are going to be very helpful to them.

Thank you very much, Dr. Sheffield.

Mr. SHEFFIELD. Thank you.

Mr. HALL. And for your sake, and Mr. Porter's, I hope he only has a cold or the flu.

We'll have the committee that I've been kind of waiting for, the testimony from John McElroy of Hughes Communications, Inc. on international cooperation. You believe, Dr. McElroy, that I've sat through all these other hearings here, just to listen to you.

STATEMENT OF DR. JOHN H. McELROY, HUGHES COMMUNICATIONS, INC., LOS ANGELES, CA

Mr. McELROY. Thank you, sir. I hope it will be worth the wait.

Let me open by saying the statement I will make is not a statement of Hughes Aircraft policy, nor is it a statement of the policy of EOSAT, in which Hughes is a partner.

Now, having said that, let me also say that the company has put absolutely no restriction on what I've said. They said look, we can't change your past history as an executive in NASA and NOAA, go out and tell it like is. But I wouldn't want it branded as official policy, because it hasn't gone through our board of directors and so forth.

Mr. HALL. We'll listen to your unofficial official presentation.

Mr. McELROY. Thank you, sir.

I'm glad to be back here because, in the years I've dealt with the House Science and Technology Committee, it's not an undue compliment to say that this has been the one source of rational continuity in the discussion of space policy in this city.

Let me go to a very fundamental point about what we're talking about here, that I didn't choose to put in the written testimony, but I think it needs to be said. When I was an undergraduate at the University of Texas, we had some very colorful terms we applied to people who reneg on deals.

Mr. HALL. You couldn't get in SMU?

Mr. McELROY. No, sir. [Laughter.]

I wasn't that good a football player. [Laughter.]

If you put aside the colorful monikers that we might have applied, the key issue is whether or not you're going to enter into a deal with someone who has that moniker applied to them, in the future. That's basically what we're talking about.

I had the privilege of working on the document which eventually arrived on the President's desk and was signed, which committed the United States to a commercialization of the Landsat program. One of the pieces of that document, which was very—was argued with great difficulty—was the language which acknowledged that there was going to be a continuing government support of this during its early years.

The background documents which accompanied that piece of paper stated that that amount would be of the order of $500 million. That was understood. It was signed by the President. It was agreed to, under duress, by the Office of Management and Budget.

No sooner had that document been signed and agreed to than OMB began its attack on the process which it has continued to this present day. That has led to a reduction, initially, to $250 million and now to the action which you have before you in the current budget.

Let me say that this has a serious chilling effect not just on Landsat but all government industry partnerships. If you can have a situation where one party goes all the way to the head man, the President of the United States, and gets an agreement signed, sealed and delivered and then, all of a sudden, just walks away from it, then how can we go to our boards of directors, as private firms, and seriously present propositions to them?

I know that you must sit on boards of directors yourself, on any board of directors there are those who will oppose any new venture that that entity is going into. What we have done, in this example, is supply to them concrete evidence that the government is not a reliable partner and I think that is not consistent with many statements responsible members of Congress and the Administration.

Now, having said that, I know that the earth observation is an inherently troublesome subject. It's a nightmare of cross-cutting policy issues. It requires sophisticated treatment and certainly the hearing record of this committee is a strong evidence of the many facets of that. I would recommend anyone who is seriously interested in the subject to go through that hearing record.

But there is a core issue that is tucked away on this thing, and that is the place of economic benefit in our national space program. I think there is about four reasons that we do things in space: national defense, to satisfy the laudable human urge to explore new territories, to learn new scientific facts, but also—particularly around April 15 of every year—we'd like to think those investments are going to bring an economic return to the country.

Now there are only about three things that I am aware of that either do provide economic benefit from space activities or potentially will provide economic benefit. One of them is satellite communications, which is largely in the private sector. The second is earth observations taken in a general sense. The third may be materials processing, after we do further work on it.

So if you are a person who is concerned about economic benefit from your space program, then you'd best be sure that at least you nurture those three subjects. If you're going to exclude economic benefit as a rationale, then we can address the other legitimate objectives, but those are the ones that produce the benefit to the country.

Let me say that when I speak of economic benefit, I'm talking about it in the most broad and generic sense. Weather satellites, to me, produce an economic benefit, whether from improving the efficiency of industry or whether saving lives. That's an economic benefit.

Landsat produces a different set of economic benefits, ocean satellites still a third. But those are all direct economic benefits.

Now we've been very good about dispatching adventurous scouts out to explore the far reaches of the universe and the far capabilities of space systems. But sending American Daniel Boone's to open new territories for European and Japanese exploitation, sure doesn't seem like good national economics to me.

We're establishing a policy of where the United States sows and others reap. We've done that in the launch vehicle industry. We've done that in the oceanic satellite business. We're doing that in Landsat. We're doing it elsewhere, and I think that that is a practice which we just cannot continue.

Now the U.S. national effort in earth observation is a complex one. It involves NOAA, it involves NASA, the Department of Defense, and it involves our budding commercial entry, EOSAT. Now one of the questions which has come at several points during this morning's discussion has been how do we pay for some of these activities? Where does it come out of the budget?

Now let me say that I believe that you pay for it by expanding the private sector role in earth observations. I believe that you pay for part of it by reducing duplication in the current national programs. I believe that certain NASA, certain NOAA activities and certain EOSAT activities can be constructively combined and save substantial sums of money and allow us to have a more vigorous entrant into the total field of earth observations.

However, I think that before we can talk too much about that, it's essential that we talk about what earth observations really is, because earth observations isn't Landsat. Earth observations, as you heard from the two preceding scientists or the three preceding scientists, I should say, is a merger of many types of data integrated into a product which is eventually information.

I believe, therefore, that we have to talk about generic earth observation satellites in polar orbit and geostationary orbit, and that the terms Landsat, Seasat and things of that ilk are terms which are obsolete and simply will not exist at some point in the next decade or the next two decades. All we will have instead are platforms which are in space from which you provide a vantage point for simultaneous measurements of the ocean, atmosphere, and land.

Now, in the process of speaking of an expanded private sector role in earth observations however, and indeed a merger of some of these functions to save money, it's important to note that I am proposing now privatization of the National Weather Service or the functions of the National Weather Service, only that there can be an opportunity for a private entity like EOSAT to act as the agent for the National Weather Service, in collecting needed data.

We could then have a merger of function and a capture of economies of scale which could be achieved by such things as placing the EOSAT sensor on the morning polar orbiting weather satellite and acknowledging that as a joint earth observations platform. It requires policy decisions, but the economics I think would be found to be favorable.

Now, if we went through this, I believe that there would be some powerful advantages. I believe that we could, indeed, reduce the aggregate federal funds needed today to support NASA, NOAA and EOSAT. We would certainly resolve the quandry of the funding of EOSAT, and we would quit worrying so much about the viability of one niche market in earth observations, land observations, and treat this as a total market, as a whole, as a total entity.

Mr. Julyan this morning mentioned a figure of $100 million a year. That is a very small fraction of the total earth observation investment worldwide. We're talking about a half a billion dollar or so industry that's in place, that's working.

If you look in Japan, we have the MOS satellite, the JERS-1 satellite. In Europe, we have SPOT, we have the ERS-1 satellite. In Canada we have Radarsat. If we just go outside of the United States, you aggregate more than $100 million a year.

I think a second advantage is that we would allow ourself the opportunity to replace outdated government facilities with more modern industrial facilities. The government facilities are, in any event, being moved at some considerable expense, I understand, from Suitland and Camp Springs, Maryland to Silver Spring, for reasons which escape me.

Third, I would say that this would also provide NASA with an affordable means to fly some of its backlog scientific instruments. I see no problem with flying a NASA research sensor on a commercially operated satellite. That doesn't seem to be inherently an inviolate situation.

Finally, it would increase private sector responsibility for routine governmental operations.

Now, the reason I have stressed this national picture before I went into the real subject, which you asked me to discuss, of international cooperation, is very simple. The U.S., in international negotiations, has to negotiate from a position of strength. It has to have a quid pro quo. If we shoot our international entry in both legs and then tell them to go run a marathon, obviously they're going to be at some disadvantage. That is, in essence, what we're doing today.

If we also tell them to go out and negotiate an international system, we're in the same posture, because they have nothing to negotiate with. So I believe that we first must put our domestic house in order and then to begin to explore the international opportunities.

Now I believe that earth observations is an inherently international subject. I believe that there is a total inevitability about its international future. The nations of the world have traveled this path twice before. In the first case, in the formation of Intelsat. We saw a situation where a worldwide service had to be provided, where it was obvious that economies of scale could be captured in the space segment and we went down the path of creating Intelsat. It's been a highly successful organization for more than 20 years.

It is true today it's beginning to experience some competitive pressures. My attitude is, so what? If we get 20 years of good service out of an international body on earth observations, that would be a big improvement.

Secondly, in the formation of Inmarsat, we followed that path as well.

I think, then, that the key message I'd like to bring to you is that there is an international capability out there. It is extensive. It is competent. It is capable of participating in a cooperative international venture. The U.S. has skills it can bring to the table as well, providing we straighten out our domestic situation.

There is a giant earth observations market made up of the composite of weather/atmosphere oceanic and land data that can easily sustain a very, very productive private sector venture. There are ample opportunities for economies of scale internationally and domestically.

How can we go about actually doing any of this? Mr. Julyan spoke of the future plans of the SPOT system. I think it's good to look at that as an inevitable path that will be taken by a number of nations, Canada, Japan, perhaps other European nations as well. I think there is an element of national chauvinism which we share that has to be satisfied.

But I think, in every one of these countries, there will come a time when the budget officials get together and say gee, having only our flag on that satellite is an expensive luxury, shouldn't we put a couple of flags on or three flags or four flags and continue to sustain our industry in the same way that Intelsat sustains its industry, via an industrial share proportioned by the amount that you put into the venture.

Going even further than that, I've written a number of documents talking about the future of the space station. I believe that the space station has a vital role to play in future earth observations. It's just going to be a little bit further out than we had hoped.

The polar platform of the space station has all the opportunities for economies of scale, international operation that I've spoken of here, and would be a natural system to be operated by an international consortium. Perhaps in the late 1990s that might be feasible. In the meantime, I think, however it is entirely viable to consider national mergers and international mergers which are based upon the current fleet of expendable satellites.

Thank you, sir.

[The prepared statement of Mr. McElroy follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

April 2, 1987

Statement of

Dr. John H. McElroy
Vice President for Technology
Hughes Communications, Inc.

Hearings on

The Future of the Landsat System

Before the

Subcommittee on Natural Resources, Agriculture Research, and
Environment and the
Subcommittee on International Scientific Cooperation
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittees:

I am pleased to have the opportunity to speak to the subcommittees on the important topic of international cooperation in earth observations from space. My remarks will approach the subject from the perspective of one who is concerned about space applications and obtaining the maximum economic benefit from our activities in space. They are based on my personal experience as an executive in the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) and do not reflect the official positions of the Hughes Aircraft Company or of the Earth Observations Satellite Company (EOSAT), in which Hughes is a partner.

Introduction

Earth observations is an inherently troublesome subject. It is not surprising that it has been the source of so many difficult discussions in our national policy-making bodies. The hearing record of the Congress on this one subject extends over decades, and would more than fill a very large bookcase. The difficulties arise because earth observations forces one to reconcile public versus private roles, profit-making versus humanitarian objectives, national security versus commercial interests, domestic versus international outlooks, and so on.[1] Obviously, in the following I will only touch upon the most important of these issues.

My remarks will address the following subjects:

- Economic benefit and the national space program
- The U.S. national effort in earth observations
- Opportunities for national economies of scale
- The international environment in earth observations
- The changing character of earth observations
- The myth of the undeveloped market
- Opportunities for international economies of scale
- A path for earth observations
- The distant future

My discussion of the first of these subjects will focus on the need to treat economic benefit as an explicit objective of our overall space program, rather than an objective served only by serendipitous return.[2] I will then note the opportunities that exist to secure economies of scale in our space efforts at the national level. This will include the issue of public and private functions, as well as separate civil and defense functions.

After the discussion of national economies of scale, I will move on to similar economies of scale that are available internationally. This will include all of the remote sensing disciplines and not simply land observations. Finally, I will propose a possible path that could be taken to establish a secure future for earth observations.

Economic Benefit and the National Space Program

Because of the stress that I will place on economic return in the following remarks, it is important to note that my definition of "economic benefit" is a broad one, including direct benefits, indirect or socioeconomic benefits, and the underlying scientific research results that are the basis for longer term future benefits. Weather forecasts and storm warnings, for example, produce direct economic benefits through damage avoidance, indirect benefits through improvements in industrial efficiency, and socioeconomic benefits of a most fundamental nature through reductions in the loss of life. Scientific research that contributes to improvements in weather forecasts and warnings, however long term or distant they may be, can be said to produce economic benefits as well.

Using this definition, all weather, oceanic, and land observation satellites produce national and, indeed, international economic return, irrespective of whether they are NASA research, NOAA operational, or commercial satellites.

It is also important to note that my remarks stem from a belief that a significant fraction of our space activities should be directed explicitly at securing economic benefit, and not exclusively at satisfying the important and worthy human need to explore and seek adventure. This is not still another recitation of the conflict between the manned and unmanned programs, only a belief that the capture of economic return from our space program should not be neglected or pushed completely aside in order to press on to ever more distant objectives. Securing the benefits of a new frontier requires not only the dispatch of a few adventurous scouts, but a consolidation and development of the territories opened by those explorers.

Earth observations (including the study of the radiation environment surrounding the earth) is one of the few core space activities that produce economic benefit, even when the broad definition given above is used. The only other such activity of incontrovertibly demonstrated value is satellite communications (where satellite-aided navigation or search-and-rescue are treated as subcategories of satellite communications). At some point in the future, materials processing in space may move from a speculative science to a proven and economically viable application, but that must await further evidence.

Thus, if a nation is to realize an economic return from its investment in space, it must nurture these three areas and the infrastructure that makes them possible, e.g., launch vehicles and base technology. Returning to the frontier example, sending American Daniel Boones to open new territories for European and Japanese exploitation scarcely seems like good national economics. Joint exploitation would seem to be a minimum requirement.

The United States Sows -- Others Reap

These comments do not prejudge any decision as to the appropriate sector in which to conduct an economically beneficial activity (NASA, NOAA, or a private firm). They also do not prejudge the manner in which a nation may choose to foster or nurture efforts, e.g., by direct funding, assignment of responsibility, or statement of policy. A nation may choose to nurture the activity in any of the sectors, using methods that are pertinent to that sector and consistent with the nation's governing philosophies.

However, if the United States is to capitalize on its very large past investment in space, it must make an explicit decision to nurture the core space areas listed above. It must do so in a sophisticated manner with a full understanding of the complex interrelationships among the public, private, and international environments. If the United States chooses to ignore the issue, or addresses it badly, then it leaves the benefits for other nations to collect -- as it is currently so doing.[3] It should also not be overlooked that many, if not most, of those benefits are obtained from the U.S. market.

The United States is the largest single market for launch services and created the international launch service industry. It opened the door for Europe, Japan, and China to serve the market, and only the efforts of the Department of Defense are sustaining a niche for U.S. industry.

The United States created the oceanic satellite with the NASA's pioneering spacecraft, Seasat and Nimbus-7, and furthered the concept with experimental imaging radars carried on the Space Shuttle. The United States is the largest future market for maritime services that will evolve from these early programs. The successors to Seasat and Nimbus-7 are not from the United States, however, but Japan's just-launched Marine Observations Satellite (MOS-1), Europe's first Earth Resources Satellite (ERS-1), Canada's Radarsat, and Japan's first Earth Resources Satellite (JERS-1).[4] The United States can only muster a joint project with France called Topex-Poseidon, and has recently cancelled the joint U.S. Navy-NASA Navy Remote Oceaning Sensing Satellite (NROSS) project. The United States created the capability and now leaves the field for others to collect the benefits.

The United States created the land-observing satellite with the highly successful series of Landsats-1 through -5, and created an international user community and network of receiving stations -- each funded and operated by the host country. As in the other examples above, the United States is the largest single market for land observations data. As of the date of these hearings, the recipients of the benefits of that work will be France's SPOT system today and Japanese systems tomorrow. EOSAT will soon need to purchase French data to sustain its customers, and the international ground stations that NASA helped create will be the marketing outlets for SPOT-Image.

The U.S. National Effort in Earth Observations

The relevant segment of the U.S. effort in remote sensing from space includes NASA's earth sciences program, NOAA's operational polar-orbiting and geostationary satellites, the nascent EOSAT commercial activity, and the Air Force's Defense Meteorological Satellite Program (DMSP). All receive federal funds, although EOSAT's funding level has been insecure in spite of being governed by a federal contract.

NASA's program is science driven, rather than applications driven, and involves largely speculative new instruments of such cost and complexity that they have no obvious tie to future governmental or commercial operational sensors. The NASA program will, however, develop scientific information that will ultimately be of great value to those programs[5], but the direct heritage from the NASA instruments to, for example, a commercial instrument is likely to be limited. NASA relies upon the private sector to develop the sensors under NASA and university scientific guidance, build the spacecraft bus, launch the satellite, operate it in orbit, and perform most of the data processing. Thus, there is a very large private sector role at present.

NOAA's program is applications driven, with a heavy multidisciplinary and international character. NOAA operates two satellite observing systems, one in sun-synchronous, near-polar orbit and a second in geostationary orbit. The low-altitude polar-orbiting system is made up of two spacecraft, one that crosses the equator in the early afternoon and one that crosses in the early to mid-morning.[6] The latter orbit is similar to that of Landsat. The geostationary system is also made up of two satellites, one directing its attention from nominally the Mississippi River eastward to the coast of Africa and a second westward into the Pacific Ocean.

NOAA's polar-orbiters are coordinated with the Air Force's DMSP and carry a complementary, but different, set of instruments. One of the differences stems from the measurements needed by the civil weather services of the world versus those needed by the Air Force. A second difference stems from the origin of some of the NOAA instruments, provided as they are by foreign countries. The NOAA low-altitude satellites carry an Advanced Microwave Sounding Unit (AMSU-B) from the United Kingdom, a data collection and platform location system (ARGOS) from France, and a search and rescue system that is jointly provided by Canada, France, and the United States and coordinated with a functionally identical system on the Soviet Union's COSPAS satellites. The search and rescue system has been directly responsible for saving more than 700 lives, with still more being saved every week.[7] The NOAA polar orbiters are de facto international satellites.

NOAA's geostationary satellites, while not containing internationally provided sensors, are also part of a de facto international system. The eastern U.S. satellite is flanked by Europe's Meteosat, while the western U.S. satellite's coverage interlocks with that of Japan's Geostationary Meteorological Satellite (GMS). India's Insat connects the coverage of the Japanese and European satellites. Technical agency officials of each of the parties coordinate this international ring of satellites.[8]

NOAA's polar-orbiting and geostationary satellites were originally designed to serve the meteorological community. As their capabilities developed, however, their utility to the oceanic community became obvious. Because of their operational continuity, they also became appropriate carriers for data collection and search and rescue transponders. Finally, the moderate resolution atmospheric and oceanic sensors were found to have utility in land observations as well. Thus, the original weather satellites have evolved into multidisciplinary earth observations platforms.[9]

In the previous discussion of NASA's research program, it was shown that the private sector role is pervasive. The same is largely true for the private role in NOAA's program, and in the Air Force's DMSP. In both instances, the federal role is one of specifying requirements and seeking funds, while that of the private sector is building and operating the required systems.

Landsat was born before the evolution of the weather satellites was very far advanced, at a time when unidisciplinary satellites were the norm. That norm continued through the era of Seasat as well. Progressing through a series of five NASA satellites, the responsibility for operation of the fourth and fifth was transferred first to NOAA and finally to EOSAT. The spacecraft carry two multispectral imaging devices, one providing four spectral bands at 80-meters ground resolution and the other providing seven bands at 30-meters ground resolution. The orbital altitude and equator crossing time of the Landsat and the morning NOAA polar orbiter are sufficiently close to one another that a merger of function can be considered.[10] The sensor capabilities are complementary to those of France's SPOT satellite -- Landsat has more bands, and bands that extend farther into the infrared, while SPOT has superior spatial resolution.

In spite of the firm decision to transfer the Landsat system to EOSAT, no lasting decision has been made to accompany the transfer with adequate funds. These hearing are themselves testimony to the turmoil in our space policy making apparatus.

Opportunities for National Economies of Scale

It is appropriate to first dispose of one of the false economies of scale that is frequently raised; that is the merger of the NOAA polar orbiter system under the Air Force's program. Putting aside the political implication of a further downgrading of the civilian space program in deference to that of the Department of Defense, that merger is infeasible and not in the best interests of the nation or the Department of Defense.

As noted above, the sensors on the two system are different. The primary civil sensor provides precision vertical temperature and water vapor soundings for incorporation in the world's twice daily synoptic forecast models. The Air Force does not have a sensor of comparable precision, and lacks the requirement to deploy one. It would be necessary for the Air Force to adopt the civil sensor (a substantial part of which is supplied by the United Kingdom) -- and the international ties of the civil system to ensure that the nation continues to benefit from the quid-pro-quo exchange of weather data. The Department of Defense is a major beneficiary of NOAA's international ties, and yet to attempt to sustain them under national security management would be ill-advised at best and infeasible at worst.

The primary sensor on the Air Force satellite is a higher spatial, but radiometrically less precise, imaging system that is especially tailored to special defense needs. It lacks the capability of the equivalent civil sensor to map ocean currents, coastal upwellings, and vegetation changes. It would be necessary to combine the civil radiometric requirements with the spatial resolution requirements of the Air Force, and append the international ties as well, but a cumbersome and expensive sensor would result.

The fate of the international contributions from France, Canada, and the United Kingdom and the SARSAT-COSPAS search and rescue program under Air Force management are difficult to imagine. When all of the above considerations are carefully examined, it will be found that merger of the NOAA and Air Force polar-orbiting weather satellites is unwise and uneconomic.

On the other hand, duplicative functions are being maintained by NASA, NOAA, and EOSAT as a matter of current national policy. NASA has its ground stations, NOAA has its ground stations, and EOSAT will have its own as well. Similarly, NASA has control centers, NOAA has its own, and so does EOSAT. The same can be said of data processing and other support functions. Finally, NASA has requirements for the flight of earth observations instruments, NOAA must continue to fly its instruments, and EOSAT needs a vehicle to carry its sensors. In all cases, the federal budget is asked to fund the spacecraft, instruments, and ground systems, although the responsibility to EOSAT is expected to diminish with time, except for the continued purchase of data on an as required basis.

An Expanded Private Sector Role in Earth Observations

At the national level, it would appear reasonable -- as a first step -- to have a single, civil, federally funded polar-orbiting satellite system operated by the private sector. The means I will present to accomplish this objective will be to broaden the charter of the current U.S. earth observations designee, EOSAT. I will give a few of the principal characteristics of an expanded entity in the following review.

First, the private entity would be charged with providing and operating two space platforms in polar orbit. One would have an early afternon equator crossing time, and the second would have an early to mid-morning crossing time. The orbital altitude would be nominally 850 km. Initially, the spacecraft would simply be advanced expendable satellites that would evolve from the current Advanced Tiros-N (ATN) series.[11,12] In their first generation, they would be neither serviceable nor capable of altitude adjustments, as no polar orbit servicing capability is likely to be available in their lifetime.

The two platforms would first and foremost serve as the successors to the current NOAA polar-orbiting satellites, which employ the ATN series. NOAA would fund the flight of their instruments (meteorological sounding and imaging, data collection, search and rescue, and others) on a cost reimbursable basis. In some instances, NOAA would simply serve as the agent for a foreign-provided instrument and fund the marginal integration costs.

It should be noted especially that no "privatization" of the National Weather Service or its responsibilities is proposed. The responsibility for all forecast and warning related functions would remain with NOAA. Instead, what is proposed is that EOSAT be NOAA's agent for earth observations data, rather than provide the data itself. NOAA would define the data requirements, or even provide the sensors to be flown if that were judged appropriate, and determine the policies under which data is distributed domestically and internationally. EOSAT would not "sell" weather data to the public, but deliver it under contract to NOAA for such distribution as NOAA sees fit.

Second, in addition to the NOAA instruments, the morning platform would carry the successors to the multispectral imaging devices of the current Landsats 4 and 5. These would be provided by EOSAT. Further, both platforms could carry -- as appropriate and technically feasible -- other commercial earth observations instruments that might be provided by EOSAT.

Third, on a space-available basis, NASA could then be provided with the opportunity to add research instruments on a cost-reimbursable basis, and the opportunity could be extended to others as well. For example, the instruments for the recently cancelled NROSS satellite might find a home here. This step would not eliminate all possible need for NASA spacecraft in polar orbit, but it would provide additional flight opportunities at relatively low cost.

Thus, full operational responsibility for two multidisciplinary polar-orbiting space platforms would be vested in EOSAT. The business base of the U.S. designee would be expanded from the narrow charter of only land observations to encompass serving as the government's agent for other observations and services as well. As the agent, EOSAT could receive government-developed devices for integration onto the platforms, or it could respond to a specification for particular data and then manage the development of an appropriate sensor or the modification of an existing or operational sensor to satisfy the need.

Fourth, because EOSAT would be acting as the government's agent, and limited by some form of regulatory regime in the amount of fees it can charge, it would be appropriate to have all necessary government equipment and facilities needed to carry out this responsibility transferred to EOSAT at no cost, or in the case of any required federal property leased at marginal cost. The role that EOSAT would play would be analogous to a dominant common carrier (a carrier's carrier may be the most appropriate analogy) in the telecommunications industry.[13,14] It would be subject to regulation and the approval of formal published tariffs. As such, charging for federal property would simply change the rate base that dictates a tariff. This would result in a pointless and circular flow of funds.

As I noted above, this is only a first step. The geostationary weather satellite facilities of NOAA are colocated with those of the polar-orbiting satellites. To capture the maximum economies of scale, it would be appropriate to include the geostationary satellites and their associated ground systems as well. There are obviously powerful benefits that would flow from the above steps. I will enumerate some of them in the succeeding discussion.

First, the aggregate federal funds required today to support NASA, NOAA, and EOSAT would be reduced. The current quandary regarding the funding of EOSAT and the viability of the land observations market would be resolved. The latter market would become simply one of several business areas in which EOSAT could work.

Second, outdated NOAA facilities at Suitland and Camp Springs, Maryland would be closed and replaced by modern consolidated facilities. Those facilities will have to be replaced in the future in any event, and the replacement costs can be reduced through consolidation with the more modern Landsat facilities.

Third, NASA would have an affordable means to fly some of its backlogged scientific instruments. The scientific community that has experienced such great difficulties in the aftermath of the Challenger would have a new outlet for its need to fly instruments -- especially the smaller instruments that seem to have no logical home for the foreseeable future.

Fourth, private sector responsibility for routine governmental operations would be expanded, and governmental resources deployed elsewhere. This is in keeping with the stated objectives of many respected leaders of both major political parties. Not insignificantly, it also permits the scientists and engineers who are involved in remote sensing to work in a less contentious, politically charged environment. Present government personnel would find greater freedom of operation and opportunity outside of the narrow confines of the Civil Service system. And, perhaps, most importantly of all, the assignment of this responsibility to the private sector with an appropriate scope of action largely removes the threat to a continuity of land, atmospheric, and oceanic observations data. In particular, if appropriately structured at the outset, a buffer could be provided between sustaining a flow of data and the annual budget cycle.

Finally, and in preparation for the next section of this testimony, the United States would not be placed in an untenable negotiating position in future discussions toward the internationalization of earth observations.

The International Environment in Earth Observations

There is now a highly skilled international community in earth observations. That community is capable of not only using effectively the data from satellites, but is also capable of participating in the development of the space and ground hardware needed to produce the data. More importantly, that user community has recognized far better than the United States the long term benefits of explicit, objective knowledge of the earth and its dynamics. In the succeeding, I will discuss briefly the status of international activities in each of the major observation disciplines (atmospheric, oceanic, and land) and the two ancillary systems that accompany earth observations satellites (data collection and search and rescue).

Atmospheric Observations and Ancillary Instruments - As noted above, Europe, Japan, and India have deployed geostationary weather satellites. The Soviet Union has committed to do so in the future. Also as noted above, the United Kingdom is providing one of the operational sensors on the U.S. polar-orbiting weather satellites. On those same satellites, France is providing one of the ancillary devices, the data collection system, and France, Canada, and the United States are jointly providing the second, the search and rescue system. Finally, the Soviet Union maintains its own polar-orbiting satellite system, called Meteor. Thus, the expertise needed to provide these systems is widespread. At the other end of the application spectrum, more than 100 countries use the data from these satellites on a daily basis.

Oceanic Observations - The United States pioneered in this discipline, but Japan, Europe, Canada, and the Soviet Union all have systems in orbit or under development. Therefore, although these systems have a less developed heritage than the meteorological satellites, expertise in their development and in the use of their data is also widespread, or will be in the near future.

Land Observations - As in the preceding disciplines, the United States pioneered land sensing also. Today, however, France has deployed an operational system and Japan has another under development. The Soviet Union has a variety of systems in use. India has begun the development of its own system, and Brazil has expressed a desire to do so in the future. Earth stations to receive data from these satellites have been installed in many countries, and test projects have been conducted on nearly every continent. Thus, as above, there is no shortage of worldwide expertise in this area either.

The conclusion I reach from the extensive activities underway in so many countries is twofold: (1) There is an emerging data provider and user community that can participate in future earth observation systems, and (2) There is a demonstrated international willingness to fund such activities.

The Changing Character of Earth Observations

In the preceding discussion, it was convenient to retain the historical divisions of atmospheric, oceanic, and land observations. These are, however, only obsolete historical artifacts. The understanding of a dynamic earth on all timescales is not accomplished by looking at one of the terrestrial media in isolation. The atmosphere and oceans are coupled -- not uncoupled. The lands are coupled to both atmosphere and oceans. The radiation environment above the earth couples with the atmosphere.

The future of earth observations lies in multidisciplinary observations taken simultaneously and from a common vantage point.[15] Integrated data sets are required for basic and applied research, and for commercial applications as well. The mariner needs the present and future state of both the atmosphere and the seas. The flood control specialist needs topography, vegetation maps, and meteorological data. The commodities speculator needs historical climatological data, past and present crop acreage, and meteorological data of the recent past, present, and relatively near-term future.

Still another change is the evolution from the brief measurement that demonstrates feasibility to the long-term, consistent exploitation of measurement capabilities that have been created. Operational needs are obviously long term, but scientific research is as well. The emerging studies of global dynamics (or "Global Change" as it has been dubbed) bear far closer resemblance to operational activities of the past than they do to research missions.[16]

The implications of these changes for the future of earth observations are profound. The unidisciplinary satellite of the past, and even of the near future, will vanish. The sophisticated data user will require timely data from multiple sensors and platforms; the flow of these data to the user must be managed with an effectiveness that exceeds any past practice. The satellites and their sensors will be knitted into an overall space and terrestrial information system that will serve many data users, whether for research or applications.[17] The operational efficiency of the information system will be of vital concern, and I believe that its management must be placed in the private sector. Further, the move to multidisciplinary observation systems implies increases in both cost and complexity, and will force data provider entities to reexamine the manner in which they approach their business.

The Myth of the Undeveloped Market

One of the oft-repeated statements is that there is at best a latent market for earth observations data and that a protracted period of time is required before a self-sustaining market can be developed. As in most oft-repeated statements, it contains an element of truth, but there is also an element of error.[18]

We have chosen to open a narrow market niche to the private sector and now demand that business stand or fall within those narrow confines. It is as if the early American department store were banned, and only single product stores permitted. A few profitable single product stores would have succeeded, but their overhead would have been high -- and passed on directly to the consumer. Most would have failed, and the public denied those products. Of course, this did not happen; multiproduct department stores evolved, overhead was shared across product lines, and the consumer benefitted from lower costs and greater product diversity. This is not an overly simplistic analogy to the manner in which we have approached the transfer of remote sensing to the private sector.

Here we are faced with a situation in which the United States is spending several hundreds of millions of dollars per year to secure earth observations data for civil governmental purposes, largely in the NOAA budget. The nations of the world are spending still more. The purpose of these investments is not to build spacecraft and launch vehicles, but to obtain needed data. These investments are not an indication of a latent market, but of a robust one.

Why then is there the perception of an undeveloped market that is incapable of sustaining a private venture? First, we exclude the governmentally required earth observations data from the equation, and demand that the venture be supported by only private markets. We pretend that the government's need for earth observations data can be decided on a year-by-year basis, that -- while we may need land or weather data this year -- we may dispense with it next year. Second, we segment the market and demand that the government market be served by government systems and the private market by private systems, even though no sage can distinguish private from public data bits as they flow from an earth sensor -- only their later processing and use can create the distinction.

Earlier this year, I wrote[18], "The complaint that there is no viable market for a private Earth observation venture has almost become scripture. But if Earth observation as a whole is considered, it is patently untrue. If you limit the definition of an Earth observation system to one that uses only Landsat-type sensors, that is confined to its own platform, and that has its own data processing network, but then deny it support by government purchases and allow that same government to distribute similar data free of charge, you've described a truly bad business venture." That is the venture we have created.

Opportunities for International Economies of Scale

To this point in the testimony, I have stressed our domestic situation and the growing competitive foreign capability. The latter is a problem to us, if we do not resolve our domestic issues. If we resolve them, however, the growing foreign capability is an asset that can serve to everyone's advantage.

Assume for a moment that we have taken appropriate steps to establish a strong domestic entity -- a securely funded EOSAT with the expanded responsibilities described previously. This is a condition precedent to any approach to the international community; one cannot negotiate from a position of weakness.

The proliferation of national systems that I described has manifold roots. First, nations obviously desire and need earth observations data. Second, they are concerned that other nations may "see" things of which they are unaware. Third, they wish to develop the skills of their industry for use in space and other areas. Fourth, they wish to demonstrate a national technological capability.

The first two roots are matters of secure data access -- rather than ownership of national systems. The last two roots are largely matters of industrial share that have been solved in other international consortia, although the fourth root is as rooted in politics as it is in technology. These considerations all lead toward the development of first- and perhaps second-generation national earth observations systems.

As time goes on, however, national budget authorities become less and less interested in repeated demonstrations of prowess, and more and more concerned with sustaining needs at the lowest cost. If a nation can assure the availability of earth observations data and maintain a continuing view of what those data are showing, international cooperative ventures become feasible. If a nation can secure work for its industry in proportion to its willingness to contribute resources, another step towards international cooperation can be taken. Finally, if the cost to a nation via a cooperative venture is less than it would be through the continued maintenance of a national system, then it may find equal satisfaction from seeing its flag as one of a number on a spacecraft, rather than by itself.

The nations of the world have travelled this path at least twice before,once in the creation of Intelsat, and a second time in the creation of Inmarsat.[19] In both instances, there were acknowledged global needs and a service that was of necessity global as well. The same is true of earth observations. All countries require earth observations data, and not of only their own territories. Atmospheric and oceanic patterns obviously cross many boundaries, but data of the land have scientific and commercial interest that extends beyond national boundaries as well. Thus, earth observations involves data that are taken everywhere, and distributed everywhere too. That is a simple definition of an inherently international subject.

In telecommunications, there was a judgment that national technological capabilities would not be harmed by the joint development of the space and ground hardware that was required, and that valuable cost sharing would be obtained. The same potential is true for earth observations, but the starting point is even more favorable than it was for communications satellites. When Intelsat was conceived, international capability in communications satellites was very limited; it had to be taken as an act of faith that other nations would be able to secure their fair industrial share. In earth observations, on the other hand, other nations have already demonstrated the capability to contribute technologically as well as financially. They can negotiate with confidence that their industry will have a full opportunity to participate from the very outset.

Further, each member government of Intelsat and Inmarsat maintains a continuing interest and oversight of the entities' operations. In most instances, the representatives to the bodies are governmental officials associated with their national Post, Telephone, and Telegraph (PT&T) administrations. The United States is represented by a private firm, but that is not an indication of a lack of government interest, only a differing approach to oversight. If telecommunications is deemed to have governmental importance, earth observations must also. The ultimate client for most earth observations data is the government. Whether meteorology, oceanology, the state of the ionosphere, national or international agricultural assessments, enhanced mapping, or a myriad other applications, the need for data is a governmental one. Thus, the model of an international body governed by designated national representatives is appropriate to earth observations, just as it is to international telecommunications.

Finally, in communications there were obvious economies of scale that could be captured in both the space and ground segments. Those same economies of scale are available in earth observations. There is no need for a continued proliferation of national systems. Many functions can be combined into a substantially smaller number of satellites than are now planned. Two space platforms in polar orbit would suffice for most of the low-altitude missions. The ring of geostationary weather satellites could use a common design (with no greater diversity than is necessary between, for example, an Intelsat for the Atlantic versus one for the Pacific), and benefit from the savings in larger scale manufacture and interchangeability for mutual backup.

Therefore, following the example of Intelsat and Inmarsat, one can imagine the formation of an international body that I have elsewhere dubbed "Envirosat-International."[9] I dubbed the U.S. representative "Envirosat-USA", and would expect that entity to be the expanded EOSAT that I discussed before.

A Path for Earth Observations

The United States cannot afford to simply walk away from one of the premier applications of space technology. Earth observations is too important for the United States to be a bystander that is dependent upon other nations to meet its needs. The data from earth observations systems relate principally to governmental functions, and we cannot expect the private sector to assume a role that only the government can.

Therefore, the first step toward resolving the current dilemma in earth observations is to eliminate the ambiguity in the support to our national designee, EOSAT. I am a very strong supporter of international cooperation in earth observations, and I believe that there is an inevitability to it. What is not inevitable is the role that the United States will play. In the formation of Intelsat, the first step was the creation and support of our national designee, Comsat. If we are to achieve the cost savings and efficiencies that can flow from internationalization without sacrificing our own legitimate national interests, we can only do so by having a strong U.S. designee.

After that step is taken, the United States can take the lead in inviting other nations to participate in the formation of an international body to conduct operational earth observations. That process could begin by issuing a call for a convention of national representatives. The Department of State could coordinate the invitations, in consultation with NASA, NOAA, and EOSAT. There is a strong foundation for action that stems from the numerous international coordinating bodies that are already in place. To name only a few, there are[20,21]:

- Coordination of Geostationary Meteorological Satellites (CGMS)
  [ESA/Eumetsat, India, Japan, USSR, and USA]

- Landsat Ground Station Operators Working Group (LGSOWG)
  [Argentina, Australia, Brazil, Canada, ESA, India, Indonesia, Italy, Japan, People's Republic of China, South Africa, Thailand, and USA]

- Coordination of Land Observing Systems (CLOS), Coordination of Ocean Remote Sensing Satellites (CORSS), and Coordination of Earth Observations Satellites (CEOS)
  [ESA, Canada, France, and USA]

- International Polar-Orbiting Meteorological Satellite (IPOMS)
  [Economic Summit partners (European Communities, France, Federal Republic of Germany, Italy, Canada, Japan, and the USA), Australia, and Norway]

These organizations, and there are others that could be cited as well, demonstrate that nations have a strong tradition of cooperation in earth observations. The creation of an international body can build upon that tradition.

The Distant Future

While the above discussion has focused on a straightforward extension of current technologies, there are even more exciting prospects for the distant future. NASA, serving as the agent for the United States, has invited a number of countries to participate in the development of the Space Station Program. That program will deploy in the mid- to late-1990's a core inhabited station in low-altitude, low-inclination orbit, a co-orbiting platform nearby, and two astronaut-serviceable platforms in polar orbit (one provided by the United States and one by ESA).[17] If this dream is realized, including a manned capability in polar orbit, the low-altitude satellites of Envirosat-International may become one of the first commercial customers for the Space Station. The potential economies of satellite servicing and the increased size and complexity of the Space Station Polar Platforms would then be open to exploitation.

Conclusions

Earth observations will never be a subject without controversy, but there are means to reduce the level of that controversy. One of the means is simple, a recognition that the pursuit of economic gain is a vital part of our national space activities and an acceptance that it may require a modest amount of support. Our current practice seems to be one of funding the expensive early missions that prove a new capability and then neglecting the exploitation of that capability. The emergence of space powers around the world has meant that the capabilities do not simply lie fallow when we do not choose to exploit them, but that others will do so in our place.

The U.S. national effort in earth observations is a large and expensive one that includes NASA, NOAA, the Department of Defense, and the newly established commercial entry, EOSAT. The effort includes polar orbiting satellites of all of these entities and geostationary weather satellites of NOAA. While I do not support consolidation of civil activities with those of the Department of Defense, there are ample opportunities for realizing economies of scale on the civil side. The government should not fund duplicative efforts among NASA, NOAA, and EOSAT, but should capitalize on the similarities among the programs to achieve economies.

I propose that the economies be achieved by expanding the role of EOSAT. EOSAT can be allowed to assume responsibility for NOAA's polar-orbiting and geostationary weather satellites and their associated command, control, and data processing facilities. EOSAT could then merge the Landsat and polar-orbiting NOAA satellites (the Advanced Tiros-N series) into an integrated system. The geostationary weather satellites would share some elements of the ground system as well. In addition to achieving economies, this action would broaden EOSAT's business base and make it a more effective international competitor or U.S. designee in seeking further international cooperation in earth observations. This action would also be consistent with employing the private sector to meet governmental needs wherever feasible. EOSAT's role would be that of serving as an agent for NOAA. NOAA would retain full responsibility for defining data needs and the policies for data distribution. EOSAT would not be entering the weather forecasting arena, only offering the nation a more efficient means to obtain that and other data.

International capabilities in earth observations are expanding rapidly and will continue to do so over the next decade. Foreign systems will be deployed that address all of the major disciplines of earth observations (atmosphere, ocean, and land). The U.S. NOAA satellites are also part of that expanding international capability, carrying as they do instruments provided by a number of countries and coordinated as they are through a number of international channels. The increasing international capabilities are also accompanied by a change in the character of earth observations. The unidisciplinary weather, ocean, or land satellite is rapidly becoming obsolete, as both science and applications users of data move to increasingly multidisciplinary uses. This trend is one of a merger of smaller systems into larger, more complex and costly integrated systems.

When earth observations is taken as a whole, it is found to be a vigorous market in which there are hundreds of millions of dollars being invested every year. This is not only the isolated market for Landsat data, but the overall, and governmentally dominated, market for all kinds of earth observations data and products. Successful commercial ventures can be built upon this larger market; they are highly risky in narrow, niche markets. Earth observations markets are, however not simply diverse, they are inherently international in scope.

Just as the potential for economies of scale was noted on a national level, the same potential exists internationally. Nations have many motives for deploying space systems, some involve a need for data, others involve technology, and some prestige. As long-term, routine operations are undertaken, however, nations will seek economies of operation as a major objective. In the past, the telecommunications industry was faced with a similar situation, and Intelsat and Inmarsat were created. Those successful models can be followed in earth observations.

I propose the formation of a new international body for earth observations, which I will call "Envirosat-International." The U.S. representative would be "Envirosat-USA", and would be a revitalized and expanded EOSAT. The body would be formed in a process that would begin with the convening an international meeting of representatives in an analogous way to the manner in which Intelsat and Inmarsat were formed. There are many exisiting and past coordinating bodies that will provide a backdrop to the work of the international convention.

For the first, and possibly second generation, of satellites, Envirosat-International will rely upon expendable satellites that are evolutionary in design from current satellites. Late in the next decade, however, the Space Station Program may lead to the development of large, astronaut-serviceable polar platforms that will lead to even further economies and capabilities.

I see no reason to be pessimistic about the future of earth observations, or the role that the private sector can play in that future. The potential is there, but firm leadership is required to realize it.

References

1. McElroy, J. H., "Remote Sensing: The Needed Government-Private Sector Partnership in Research and Development," Keynote Address, The 5th GEOSAT Flagstaff Workshop, Remote Sensing: Goals and Directions for Research and Development, November 4-8, 1985, Flagstaff, Arizona

2. McElroy, J. H., J. Clapp, and J. Hock, "Earth Observations: Technology, Economics, and International Cooperation," Invited Paper, National Academy of Engineering and Resources for the Future Symposium on Explorations in Space Policy: Emerging Economic and Technical Issues, June 24-25, 1986, Washington, DC

3. Space Applications Board, "Remote Sensing of the Earth from Space: A Program in Crisis," Report of the Committee on Practical Applications of Remote Sensing from Space, Space Applications Board, National Academy of Sciences Press, Washington, DC, 1985

4. McElroy, J. H., "Earthview -- Remote Sensing of the Earth from Space," in A. Schnapf (ed.), Monitoring Earth's Ocean, Land and Atmosphere from Space -- Sensors, Systems, and Applications, Vol. 97, Progress in Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics, New York, 1985

5. Arvidson R.E., D. M. Butler, and R. E. Hartle, "Eos: The Earth Observing System of the 1990's," Proc. IEEE, Vol. 73, No. 6, June 1985, pp. 1025-1030

6. Smith, W. L., W. P. Bishop, V. F. Dvorak, C. M. Hayden, J. H. McElroy, F. R. Mosher, V. J. Oliver, J. F. Purdom, and D. Q. Wark, "The Meteorological Satellite: An Overview of Its 25 Years of Operationa As a Weather Analysis and Forecasting Tool," Science, Vol. 231, No. 4737, 31 January 1986, pp. 455-462

7. McElroy, J. H., and J. T. Bailey, "Saving Lives at Sea Via Satellite," Sea Technology, Vol. 26, No. 8, August 1985, pp. 30-34

8. Johnson, David S., "Twentieth Anniversary of the World Weather Watch: Opportunities and Outlook for an Improved WWW," World Meteorological Organization Document No. 608, Geneva, Switzerland, 1983

9. McElroy, J. H., "The Future of Earth Observations from Space: A Speculative Vision for the Space Station Program," Ninth Annual Wernher von Braun Memorial Lecture, National Air and Space Museum, Smithsonian Institution, Washington, DC, January 30, 1986

10. McElroy, J. H., and S. R. Schneider, "The Polar Platform for Earth Observations," in P. M. Bainum and F. von Bun (eds.), Europe/United States Space Activities, Vol. 61, Science and Technology, American Astronautical Society, Univelt, San Diego, California, 1985

11. Schwalb, A., "The TIROS-N/NOAA A-G Satellite Series," NOAA Technical Memorandum NESS 95, Washington, DC, 1982

12. Schwalb, A., "Modified Version of the TIROS-N/NOAA A-G Satellite Series (NOAA E-J) -- Advanced TIROS-N (ATN)," NOAA Technical Memorandum NESS 116, Washington, DC, 1982

13. Snow, M. S., *International Commercial Satellite Communications, Economic Political Issues of the First Decade of INTELSAT*, Praeger, New York, 1976

14. Pelton, J. N., and M. S. Snow (eds.), *Economic and Policy Problems in Satellite Communications*, Praeger, New York, 1977

15. McElroy, J. H., and S. R. Schneider, "Utilization of the Polar Platform of NASA's Space Station Program for Operational Earth Observations," NOAA Technical Report NESDIS 12, Washington, DC, September 1984

16. Bretherton, F. P., "Earth System Science and Remote Sensing," *Proc. IEEE*, Vol. 73, No. 6, June 1985, pp. 1118-1127

17. McElroy, J. H., and S. R. Schneider, "The Space Station Polar Platform: NOAA Systems Considerations and Requirements," NOAA Technical Report NESDIS 22, Washington, DC, June 1985

18. McElroy, J. H., "Clearing the Sky," *Air & Space*, February/March 1987, pp. 60-61

19. Smith, D. D., *Communication Via Satellite: A Vision in Retrospect*, A. W. Sijthoff, Leyden and Boston, 1976

20. Hodgkins, K. O., J. M. Maclure, R. O. Masters, and R. B. Ciupek, "International cooperation in assuring continuity of environmental satellite data," *Space Policy*, Vol. 1, No. 4, November 1985, 415-422

21. Office of Technology Assessment, *International Cooperation and Competition in Civilian Space Activities*, U.S. Congress, OTA-ISC-239, U.S. Government Printing Office, Washington, DC, July 1985

Biographical Sketch

John H. McElroy is currently Vice President for Technology and Director of Galaxy Mobilestar for Hughes Communications, Inc., a subsidiary of the Hughes Aircraft Company. Dr. McElroy joined Hughes in 1985 as Director of Special Projects in the Space and Communications Group, after having served as an Assistant Administrator of the National Oceanic and Atmospheric Administration (NOAA). At NOAA he directed the nation's program in civil operational earth observations and was responsible for the TIROS, GOES, and Landsat spacecraft. From 1966 to 1982, he served with the National Aeronautics and Space Administration (NASA). His last position with NASA was as the Deputy Director of the Goddard Space Flight Center. He previously did laser research at the University of Texas (1963-1966) and worked in the U.S. Army guided missile program (1957-1963).

Dr. McElroy is a graduate of the University of Texas at Austin (BSEE) and the Catholic University of America, Washington, DC (MEE, PhD in EE). He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), the American Institute of Aeronautics and Astronautics (AIAA), and the Washington Academy of Sciences. He is a member of the Board of Directors of the American Astronautical Society.

Mr. Hall. Dr. McElroy, are you aware that it's not OMB putting it on us, it's our own Budget Committee for Science, Space and Technology that, if the $1.1 billion cut they're kicking around, as we sit here today takes place, the space station is delayed indefinitely?

Mr. McElroy. Yes, sir.

Mr. Hall. Does that seem to be a major mistake?

Mr. McElroy. I believe it is, sir.

Mr. Hall. And we allowed Chairman Scheuer to go fairly far afield in his presentation. Let me ask you to also go a little bit afield and talk about the potential economic benefit of SDI. It's related here. What fallout we get if we don't ever build a total bullet proof shield over our cities?

Mr. McElroy. I couldn't really speak about SDI, sir. I've been so occupied with civil matters that I just haven't even focused on that. Without a doubt, when you sustain production lines of spacecraft and the subsystems that go with it, that's got to have some benefit. I think that's obvious. But beyond that, I couldn't speak.

Mr. Hall. On page seven and eight of your presentation, you advocate that EOSAT serve as the government's agent for weather, land and ocean satellites. While this could lead to some savings, of course, of some magnitude, it raises a lot of other issues. One that you alluded to, you talked about the changes that you wouldn't recommend, regarding weather satellites.

There would have to be some changes, if we took that track. One thing we would have to do would be to change the law.

Mr. McElroy. Yes, sir. I believe that the law, indeed, would require changing. I don't think it's as drastic a change as it might appear on the surface.

Mr. Hall. Well, there's a prohibition against commercialization of weather satellites.

Mr. McElroy. Yes, sir. The reason I say it's not as great a change as might appear goes like this: NOAA has the responsibility to define all requirements for weather observations. It may be the most appropriate thing for NOAA to continue to do, even in this scenario, is to provide the instruments that collect those observations.

The issue then becomes one of what is the carrier to which you attach those instruments? You haven't really changed the responsibility for the instruments, nor have you changed the responsibility for the distribution of the data or the use of the data. What you have done, though, is you've looked at the carrier and said do I need one or two carriers? Do I have to have a carrier dedicated to EOSAT and a carrier dedicated to the NOAA polar orbiters both funded by the federal government? Or can I, the federal government, combine those two and put a basically governmental interest—instrument side by side with a commercial instrument?

If I'm paying for everything, then that doesn't seem to me to be so strange.

Mr. Hall. I'm not adverse to changing any law. That's our business. That's what we're here for.

You also stated, on page four, that NOAA's polar orbiting weather satellites, because of their internationally produced components, are de facto international satellites. What portion of the U.S. polar orbiting satellite program, is in fact, funded by any other nation?

Mr. McElroy. If you look at, first of all, the complement of sensors——

Mr. Hall. I'm talking about the cash register again.

Mr. McElroy. Yes, sir. I'd like to talk about that, as well.

If you look at the complement of sensors within the early years, the fraction was tipped very heavily in favor of the United States obviously. We contributed the most expensive sensors of all.

However, in more recent years, particularly with the decision only a couple of years ago of the United Kingdom to ride the so-called AMSU-B unit or Advanced Microwave Sounding Unit B, that is a very expensive sensor which brings the share of the instrument level up to a very, very fair balance.

Now we still provide totally the bus that it rides upon. One of the things that I began, when I was still in NOAA, was an effort to expand contributions to those polar orbiting spacecraft from other nations. In fact, that's where the germ of the idea for an international system really originated, in my own experience.

I found other countries to be highly receptive to participating, providing they got an industrial share for their participation. It was not a controversial issue. In the discussions which were going on, having to do with the polar platform for the space station, you will find a very healthy set of instruments that have been proposed for both operational and research purposes.

Mr. Hall. Are there opportunities, do you think, for implementing some type of international consortium in the ball park, in remote sensing, even before the polar platforms are launched?

Mr. McElroy. Yes, sir. I believe that it could be based upon expendable satellites.

Mr. Hall. I can't find—I'm looking here, but I can't find my reason for having the feeling that I have here now, but we talked about international consortiums and remote sensing. I guess I'd want to ask about the feasibility of bilateral remote sensing system with the U.S. or Japan.

But somewhere I gleaned, in your testimony, that you think it's premature to even open negotiations on that? Did I misread that?

Mr. McElroy. I think that there is a—if you were to go to the Japanese, there's going to be a strong impetus on their part to, first of all, fly a system on their own, show it works, get confidence that they understand what's happening there.

Mr. Hall. And maybe even keep it for themselves?

Mr. McElroy. For a while. Then, I think, when you go to their second generation or a second generation of SPOT, then I think that's when the serious questions are going to come from their budget folks, to see exactly what the cash flow has been up to that point, perhaps acknowledge that yes, that's valuable data, but can't we reduce the capital costs in securing it.

Mr. Hall. Well, I think—I've got a lot of other questions, but I think in fairness to the other members, we'll let them submit some to you later, and I think you may as well listen for a knock on your door because as we carry out and decide just what the turf is going to be for International Scientific Cooperation Subcommittee, you sure look like a logical guy for some input for us and we'll be calling on you again.

Mr. McElroy. Thank you, sir.

Mr. Hall. Thank you for you and your company's generosity in bringing your testimony here.

This concludes the hearings for today and I do appreciate all of you and appreciate the companies that sent you here and appreciate your personal commitment to sharing your information and knowledge with the United States Congress and, through them, for the American people.

Thank you.

[Whereupon, at 12:53 p.m., the hearing was adjourned.]

○